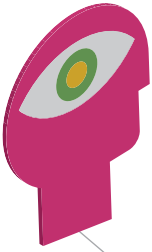
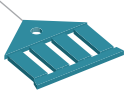
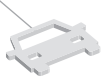
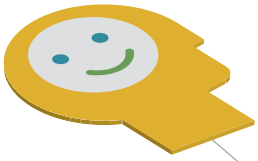
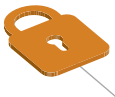
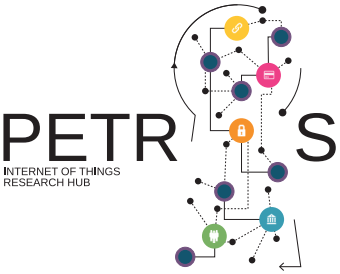
The Little Book of CREATING VALUE through DESIGN in the IoT


Chris Speed, Boyeun Lee and David Hands



Editor of the PETRAS Little Books series:

Dr Claire Coulton
ImaginationLancaster, Lancaster University

With design by Michael Stead, Roger Whitham and Rachael Hill
ImaginationLancaster, Lancaster University

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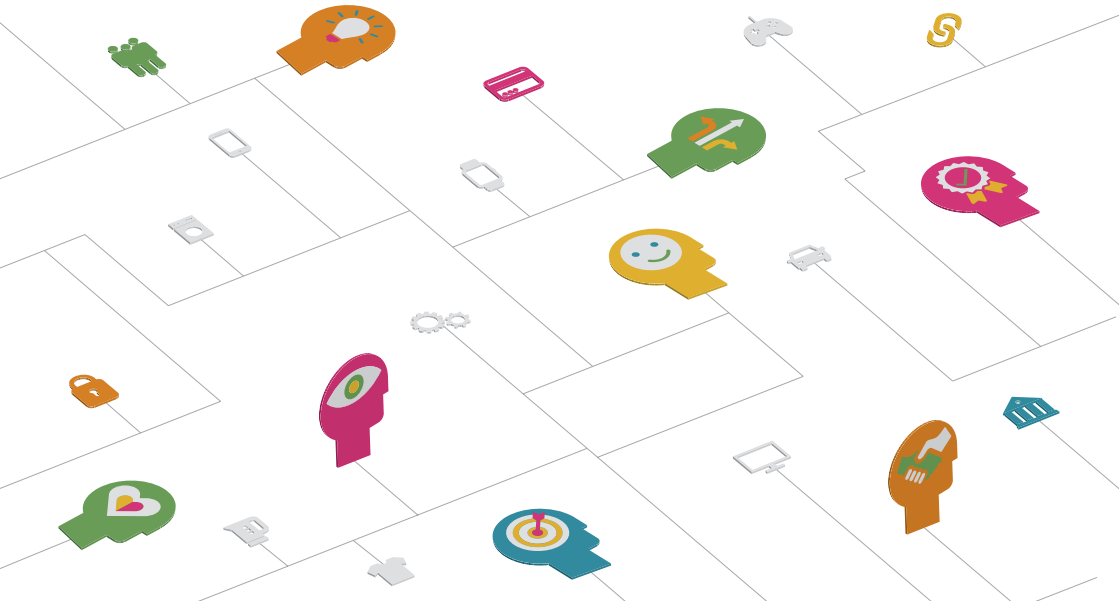
For their contributions and support in creating this book, many thanks to Claire Coulton and Michael Stead.

Contents

What this little book tells you

This little book is about creating value in the Internet of Things (IoT) within the digital economy. We explain why it is important to understand how the IoT will transform value creation and how we can use design to mediate value. Based on our research for the Harnessing Economic Value theme of PETRAS Cybersecurity of the Internet of Things Research Hub, this little book will discuss:

- The digital economy and how this differs from traditional economic models
- What we mean by value in the digital economy
- What we mean by the Internet of Things
- How value is created in the digital economy and the important role design plays in this process
- How design can add value in the IoT.
- Sphere: A new approach for designing ioT products and services
- Bitbarista: A new approach to data access and usage for the design of IoT device
- Geocoin: How to create a shared environment for speculative ideating and collaborative designing



What is the Digital Economy?

Over the last thirty years, how we produce, distribute, trade, and consume goods and services has been massively affected and changed by the internet and globally connected computer networks. What has emerged from this is known as the digital economy.

The term 'digital economy' was first coined by Don Tapscott in his seminal book "The Digital Economy: Promise and Peril in the Age of Networked Intelligence" in 1995. He later identified the digital economy as the economy for the age of networked intelligence. In addition, Nicolas Negroponte (1996) used the metaphor of shifting from processing atoms to the processing of infinite bits. In essence, in the old economy, information was physical elements or atoms, however, in the digital economy, information is commonly created and communicated in digital form: data. When people, environment and things are more interconnected through digital networks, and information becomes increasingly digitised, a new world unfolds which reconfigures social, environmental and economic relationships.

The digital economy is shaping and undermining conventional orthodoxies about how businesses are structured and managed. For example, Cloud-Computing services provided by Microsoft, Amazon Web Services, and IBM enable business customers to operate and maintain high performance expandable platforms without being limited by the inflexible capacity that a traditional factory would have. The global economy is rapidly undergoing a digital transformation resulting from ICTs such as the Internet, mobile technology and the Internet of Things. According to

recent analyses on emerging technologies that transform life, business and the global economy, the total global impact of IoT technologies could generate anywhere from $2.7 trillion to $14.4 trillion in value by 2025 (McKinsey, 2013; Cisco, 2013).

Value Creation in Traditional & Digital Economies

In the old (traditional) economy, business processes and models are commonly understood as a sequential or linear process that involves taking out cost and making the process more effective and efficient. Moreover, in this traditional economy, companies have predominantly used a push model or push strategies to push their products to as many customers as possible through effective distribution channels and compelling marketing campaigns.

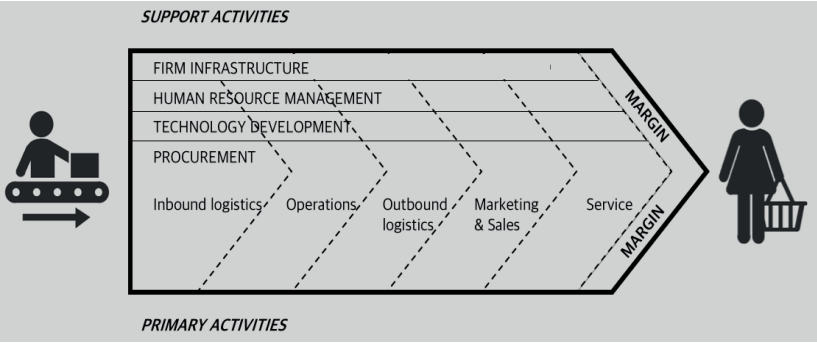


Figure 1. The value chain model in the old economy adapted from Porter & Millar's Value Chain

Value is both manufactured and created by the company and distributed in the marketplace, usually through the exchange of goods and money. Companies identify an opportunity in the market to sell a product, for example televisions, kettles and washing machines, and create a value chain that will result in a profit margin once every aspect of production and support has been paid off. Walmart, one example of a traditional grocery retailer, has achieved tremendous success with a 'push' model that transports truckloads of goods to more than 4,000 Walmart stores across the country. Although Michael Porter's value chain

model (Figure 1.) illustrates a linear value creation model, it is regarded as redundant in order to explain value creation in the digital economy because it lacks the dynamic and distributed nature of a network.

In the digital economy, value is co-created through an interplay between economic actors, business partners, competitors and customers who are exchanging value in different forms. This turn toward a more complex network of exchanges is known as a 'value constellation' (see Figure 2 below) (Normann and Ramirez, 1994). Many digital economies are now predicated upon a value constellation because the flow of data provides such immediate opportunities to revalue a product or service. For example, Alexa, Amazon's personal assistant software that supports its natural speech product 'Echo', has created a value constellation that involves many aspects of the companies' products and services. Within the value constellation, Alexa can provide you a variety of values, such as turning on and off the Philips Hue bulbs, calling an Uber ride, streaming music on Spotify, and calling Domino's pizza. In this networked environment, individuals are radically empowered to pull the products and services that they want, on their own terms and time requirements, which is called the 'pull' economy.

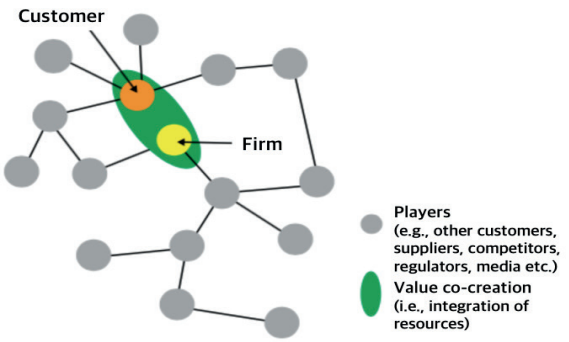


Figure 2. A value constellation model. Source: Speed, C., & Maxwell, D. (2015)

What do we mean when we talk about value?

As our economic model has changed and developed into a digital economy, how we understand value in this context has also been affected. Value is a complex and subjective concept for which a definition depends upon which economic, semiotic and social values we choose to measure the worth, goodness or fairness that a product or service provides. In understanding value in consumer contexts, we draw upon Karababa and Kjeldgaard (2013) who offer a helpful series of seven concepts for value from a socio-cultural perspective: exchange value, perceived value, social values and value systems, experiential value, identity and linking value, value as co-created and, finally, value as the co-creation of meaning. Let's expand on these concepts by providing a brief explanation using the value of an Apple Watch as an example of an IoT device.

- *Exchange Value* is the value that a consumer places on some 'thing' that they would like to exchange for money or another currency. So, for example, the price of an Apple Watch is very expensive, but we have seen many insurance companies offer them for free if people sign up for a policy.
- *Perceived value* is the worth that a product or service has in the mind

of the consumer. So the value of the Apple Watch will help the consumer to tell the time, monitor their fitness and look good to their

- *Social values and value systems* can be defined as the way in which people consider how a product will play a part in their livesin the long term, both for the individual as well as society. For example, although it might be good at monitoring your health, the Apple Watch is extremely difficult to recycle or recover parts from, so the consumer has to balance these functions with the likelihood that it will end up in landfill when it stops working.

- *Experiential Value* can be summarised by the play and fun that a product or service provides. Consumers value 'things' that are enjoyable and allow them to pursue fantasies, emotions and fun, all of which are balanced against economic values. Therefore, an Apple Watch is presented as a playful device with gaming applications that supports social interactions.

- *Identity and linking value* is exemplified in the significant role that brands play in supporting consumers' explorations of identity. In this case, the Apple Watch is a strong signifier of an attachment to the 'Apple tribe', and given its price, identifies that wearer as an affluent, tech-trendy member of society.

- *Value as co-created* introduces the reciprocal push and pull between shops and the consumer to produce both economic benefits in the form of revenues and profits, but also emotional, symbolic and social values. Thus, as more people wear the Apple Watch their value goes up for Apple as well for the wearer.

- Finally, *Value as the co-creation of meaning* is often a value that is defined, not by a company as they release a product, but by how it becomes valuable as people buy it and learn to use it in unexpected ways. As such way, the Apple Watch has proven to offer a discrete way of receiving messages in meetings without having to pick up your phone.

These definitions of value are not exclusive but they provide an insight into how value operates in society. So, a central question for designers is; how

does data change the value of products and services, when they are part of an internet of things?

So far, we have discussed the digital economy and how we understand value in this context. However, the digital economy is now adapting and changing again as the Internet of Things and its capabilities becomes more established and better understood. In this next section we discuss the Internet of Things (IoT), and the importance of design in creating value within this emerging technological system.

What is the Internet of Things?

The Internet is an open and distributed network by which people can communicate and share information. As we discussed previously, this has become a vital platform for many economic activities. However, in recent years, appliances which can be connected to the internet have expanded from regular computing devices such as smartphones and tablets, to a diverse variety of 'things', such as automobiles, thermometers, doors and lights. Within the Internet of Things, people enter new relationships with objects that have become augmented with computing and network capabilities allowing the objects to communicate with each other, sense, collect and pass data to cloud services that can process data on our behalf. Although there is not a universal definition of the 'Internet of Things', the term was first coined by Kevin Ashton in 1999.[1] In essence, the Internet of Things is regarded as an extension to ubiquitous computing in which anything and everything has the potential to be connected to the internet.

The Internet of Things is beginning to change everything; the way we work; how we spend our leisure time and how we communicate with one another. In turn, new business models are also emerging that produce new forms of value as more things and systems become interconnected. IoT also alters the way that we design, develop, manufacture and distribute products. However, the value of 'things' is deeply associated with the habits and

[1] Ashton, Kevin. "That 'Internet of Things' Thing." The RFID Journal, 2009. http://rfidjournal.com/articles/view?4986

cultures that have formed long before the internet was invented. For example, within the Internet of Things, 'Things' should be understood as complex bundles of both physical and digital systems. Whilst humans have a great deal of experience in understanding physical and tangible artefacts, we are less sophisticated in understanding the digital and intangible parts that we need to be aware of, including the flow of data between us, things and the internet. The Internet of Things represents this complex relationship between physical objects, social practices and digital systems, and requires inquisitive minds to understand how civic, cultural and commercial values are balanced against the value that a human places upon a 'thing'.

The Internet of Things is accelerating the digital economy, generating vast amounts of data in digital form, linking both the physical and digital worlds. As a myriad of products and services are becoming connected through these emergent networks, their capabilities have greatly expanded. Creating new forms of value beyond their primary function is changing our understanding of value; this, in turn, is resulting in entirely new business processes and models.

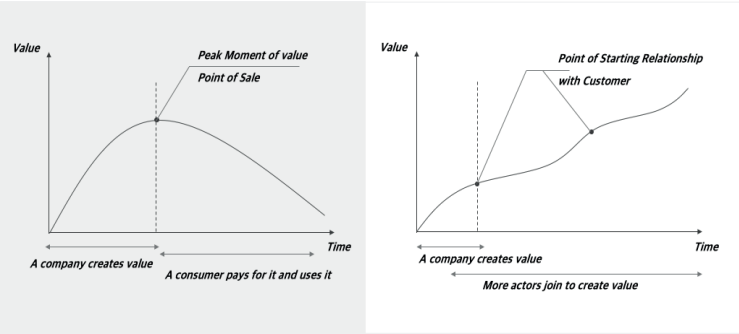
Recent studies have shown that a lack of experience in development is causing many new IoT based products to fail, therefore, we believe that design can play an important role in this new paradigm. In the next section, we focus on value creation between the traditional and the digital economies, and also present three case studies that demonstrates the importance of design in understanding user needs and behaviour and in turn, successfully creating value in emerging IoT products and services.

Why Creating Value in the IoT through Design is important?

Designers have always been skilled at mediating value. By this, we mean that they have frequently played a significant role in providing ways to further understand the customer's needs and manipulate materials, images, and actions that have been adding value to products and services for many centuries. In the old economy, a designer featured somewhere in every value chain model, uniquely positioned to increase the value of a product, or organisation, through their creative and sometimes critical insights. The value proposition, a promise of value to be delivered, was met at the point of purchase (see Figure 3 A. below), when consumers perceived value for a product or service was 'worth' the offer made by the vendor.

The different types of value between the old economy and the digital economy is illustrated in Figure 3 B.

In the digital economy, there is no critical peak moment of adding value unlike in the old economy, however, due to the underlying connection to the internet, value has the potential to be adapted on a continuous basis.



A. In the old economy B. In the digital economy

Figure 3. The emergence of Value in the Time Frame

Moreover, the state of value has a rising curve as new services are added (Figure 3 B), based on a growing constellation of internet products. This is due to real-time data frequently being analysed to construct personal value propositions. Through the analysis of large, linked data sets, organisations are thus able to keep creating and refining value propositions across a broad spectrum of stakeholders.

Let us take a household appliance as an example for clearer understanding of this dynamic relationship. In the old economy, a refrigerator was manufactured in large quantities of standardised products, based on anticipating consumer demand. Until the consumer makes payment, the manufacturer through a linear production process increases the value. While being used, the value of the refrigerator is gradually declining through continuous use and eventual failure.

In the IoT era, a refrigerator is adapted as a part of a larger heterogeneous collection of interconnected objects. According to the personalised service, the IoT refrigerator would work as a phone, personal assistant, media and nutritionist. The value of the IoT refrigerator, therefore, does not decrease while being used, instead it increases depending on what value is provided through the networked objects. The manufacturer is able to build and expand its value constellation based on data emerging from the customers' usage of the refrigerator.

The digital economy adapts constantly as novel business models are found and developed, and the flexible nature of software makes this a highly

dynamic process. Internet of Things businesses are much younger and face more complex challenges as their products and services involve both hardware and software development. Certainly, an important way to begin to create value with an IoT business model is to start with identifying latent human needs that may be concealed beneath huge amounts of customer data. In order to capitalise on this, organisations are required to cope with integrating with other applications and physical things.

As cloud services have become established and interoperability issues have become normalised, the Internet of Things remains a fertile field for businesses. In 2014, Burkitt identified that one in every six businesses would be engaged in the roll out of an IoT-based product; however, since then it has been revealed that nearly three-quarters of IoT device implementations are failing due to the lack of experience in development (Reichert, 2017). As such, using design methods to support the co-design of new products and services with potential users is far more likely to elicit unforeseen value propositions, as well as highlighting the barriers toward adoption.

Goji, a smart lock, which enables complete control over access to the home would be one of the examples of failure in IoT products and services development. The company has raised funding of over $800,000 on both Indiegogo and Fundable. However, despite successful funding, Goji has ended up with a series of significant shipping delays due to failures in production.

Figure 4. Goji Smart Lock. Source: https://www.indiegogo.com/projects/goji-smart-lock#/

How Can Design Add Value in the IoT?

Within the old traditional 'push' economies, more often than not, designers were excluded from the majority of discussions around the creation of a product's core value, and instead, were hired to add value through the use of type, colour and form at an elementary level. Developing innovative products in the past involved significant amounts of customer research and testing before investment was made in the development of an entire value chain. After launching a product, designers played an important role in adding value to a product through marketing campaigns, making sure that a product's 'worth' was commensurate with its perceived value but exceeded the costs of production. The success of these campaigns took time to understand and companies were forced to wait before understanding how a marketing campaign had influenced its consumers.

In a 'pull' economy, data provides faster feedback about the assumptions of where value lies, whilst further analytics are able to track the production of unforeseen value. The acceleration of these cycles ultimately leads to the co-production of value through the push and pull between producers and consumers and is one reason why design is now at the core of many successful products and services in the digital economy.

As we live in the digital economy where physical and digital things and

spaces are closely interconnected; creating value through products and services now requires more creative and innovative ways of thinking. This is because creating value for the IoT is affected by several interrelated factors: 1) value is created through real-time data from sensors embedded within the products; 2) value creation lies on the interplay with different actors and industries; and 3) IoT products are functionally incomplete, reprogrammable, allowing the device to perform a wide range of functions.

In the following three case studies, we illustrate the diverse ways that design can creates value in the IoT. The first example, SPHERE project, demonstrates that IoT development has distinctive challenges and processes compared to its counterpart in the old economy. In the second example, Bitbarista proposes a new approach to data access and usage for the design of IoT devices to reveal the participants' perception to the new approach. Finally, we look at Geocoin to see how it enables researchers and designers to engage wider audiences in understanding and designing novel infrastructures of smart contracts and cryptocurrencies.

1. SPHERE

SPHERE: A New Approach To Designing IoT Products and Services

The number of people living longer with one of more chronic health conditions is rising in the UK and future healthcare services in the UK will need to be prepared for a transformation from clinical settings into the home (Burrows et al, 2015). Within this context, SPHERE (Sensor Platform for Health in a Residential Environment) is a smart home system for monitoring inhabitants physical and mental wellbeing. Funded by the EPSRC for five years, SPHERE was led by Bristol University in addition with project partners from other academic institutions, industry, local government and other stakeholders.

In this project, SPHERE had to develop a new IoT ecosystem including a series of products and services. This resulted in new insights into new product development processes (NPDs) and how value can be achieved in IoT

Systems. The process and new insights are discussed below:

1. *Identifying consumer requirements* was difficult in this case, as both the clinical researchers and customers were unfamiliar with IoT systems, and they did not know the opportunities and benefits it could give them. This was resolved through a series of workshops.

2. *Technical requirements:* this took an exploratory and experimental approach, where the research team were required to address the customer requirements and design a conceptual system for the totally new IoT ecosystem.

3. *Feasibility and acceptability testing:* Moving forward it was essential to test the technology, the use of data and to assess the feasibility and acceptability issues. Sample size and amont of data were the main challenges in assessing feasibility and acceptability as a whole.

4. *Finalising the design:* Implementation of the IoT system also meant there was pressure to continuously fix bugs in the system. This means it is important to keep the design fluid, however, this increases the time and costs especially in the creation of a complex IoT system.

5. *Procurement of the system* presents challenges where there are multiple suppliers, especially in terms of quality control and increasing new suppliers in the value constellation of the IoT ecosystem.

6. *Installation* also presents challenges when working with multiple small and start-up companies – there is a need for trained technicians but this increases the cost for these companies, therefore, collaboration is essential.

7. *Monitoring and maintaining* the data collection must, of course, be continuous, especially in the application of AI to IoT systems and will inform redesign.

8. Once the IoT system and users are in full operation, the value of the system can be defined and redesigned. External experts across domains relevant to the data collection is useful here, for example, in the case of SPHERE they consulted health and air quality professionals among others.

In the SPHERE case study, although not a truly commercial IoT system, we can identify the processes and emerging insights necessary for creating

value in IoT and, more specifically, how the NPD process must be iterative and continuous. A similar model of designing IoT systems with a more detailed explanation has recently been developed by Jacobs and Cooper (2018).

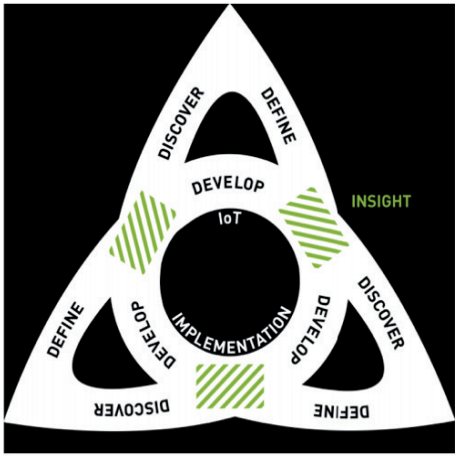


Figure 10. A new process for designing IoT products and services. Source: Jacobs & Cooper, 2018

This model presents a continuous and emergent process, where the feature and value proposition of IoT systems can continuously evolve. It also features a short cycle of discover, define and develop phases in order to reflect a huge amount of real-time data achieved through customers' experiences.

The process contains iterative cycles featuring three distinct phases in which: the discovery phase allows co-design and collaboration to identify latent requirements and attributes crucial for user experience. The define phase uses narratives, scenarios and fictions to visualise and test the design idea; then in the development phase, the products and services are created with users and lead adopters and implemented, with in-use insight revealing emergent and new qualities that feed another cycle of discover, define and develop (Jacobs and Cooper, 2018). The traits of digital economy, digital innovation, big data and digital technologies allow this new approach which is distinct to existing design and development processes. One of the differences is that the new approach is not linear, with a distinct beginning, it is a continuous and emergent process characterised by iterative feedback cycles.

This is because digital components in IoT are dissimilar to physical components. Digital components are able to modify subsidiary functionality or introduce entirely new functionality over the product lifecycle. With these distinct characteristics, the scope, feature and value proposition of IoT products and services can continuously evolve even after being launched and whilst being used. Thus, design and development process for IoT has a continuous and never-ending process cycle of discover, define and develop phases, which are enabled by an enormous amount of real- time information. It indicates that value propositions through IoT products and services are able to continually evolve in a comprehensive and fluid manner. Data is not only changing the design process but also the role of the designer(s). They no longer have to anticipate and develop generic products, with limited access to the data of customer needs as big data aids to acquire user and market information.

Summary

As we can see from the previous discussion, the process of design becomes more complicated in IoT because, unlike generating value in a traditional linear value chain, IoT is highly complex and inter-sectoral, which means it requires working and collaborating with a significant number of experts, such as device manufacturers, software developers and service providers. The more devices and complex value constellation you have, the more possibilities you have to create value. Design, within this context, should not be treated in isolation from business processes but should be used more proactively throughout the value creation process. Value in the IoT era is created through data within the value constellation. Therefore, IoT organisations need to have a robust approach toward IoT design processes that are more strategically important to contribute to the value of products and services.

2. Bitbarista

by Larissa Pschetz, Ella Tallyn, Rory Gianni and Chris Speed from the Centre for Design Informatics, University of Edinburgh

Hiding or Revealing Flow of Data

Principles of minimalism and simplicity have become increasingly influential in design, and over the past twenty years as we have consumed more complex technologies, designers and psychologists such as Donald Norman (1998) have advocated for interfaces that are clear from clutter and distraction, allowing users to focus on the task at hand. Nielsen (1994) defended the need for interfaces where dialogues do not contain information that is "rarely needed". Although much has happened in interface design since then, the drive for minimal information remains largely influential. Companies such as Apple are praised for their user interfaces that contain fewer buttons, menus and dialogue boxes. Amazon Dash offers a simple one-button device as an interface for ordering goods. Behind the scenes, however, these devices are performing increasingly complex tasks. Smartphones are constantly exchanging data to offer users the right information at the right time and connected devices such as the Amazon Dash conceal intricate exchanges with multiple stakeholders.

However, in an Internet of Things era, the extent to which users genuinely understand what is going on behind the simple interfaces is very limited. Events such as the 2011 disclosure of GPS data storage by Apple without open consent creates suspicion towards what happens behind the scenes. Discomfort levels increase as people acknowledge that data transactions may occur without explicit agreement. This is problematic, particularly as more everyday objects become enhanced with digital connectivity. This tension between interfaces that hide complexity of data transactions to increase ease of use, and the amount of background transactions that are necessary to sustain seamless interactions, argues for enhanced ways to communicate complex data processes.

With this tension in mind, the Bitbarista project (Pschetz et al 2017), developed an Internet connected coffee machine that attempts to communicate the complex data processes involved in analysing price changes and selecting best choices for near-future coffee bean supplies. The machine presents a scenario in which it would be able to collect consistent information on the state of coffee producing countries, revealing issues that affect end-prices. Nowadays, consumers are often unaware of these issues, which may include political, work and climatic changes. Instead of reducing information

overload, the machine proposes to expose its analytics process, attempting to communicate the way data is narrowed down to a few options. The aim is to explore perceptions of transactions in the Internet of Things (IoT) by presenting a scenario through which exposing this complexity would have a positive effect on how users perceive the machine.

Bitbarista

Figure 11. Bitbarista Coffee Machine

Bitbarista was designed to explore perceptions of data processes in the Internet of Things. The coffee machine is connected to the internet and serves coffee in exchange for a bitcoin contribution towards its next coffee supply. It purportedly browses online data on the state of coffee-producing countries looking for information on climate, work conditions, political situation, infrastructure, price stability and demand, and selects top-ranked options in four categories: 1) best quality, 2) lowest price, 3) lowest environmental impact and 4) highest social responsibility. The machine offers users the opportunity to choose one of these options for its next supply, paying for their

coffee accordingly. After the purchase, a new screen situates the choice within the pool of choices previously made, all anonymised, displaying the supply most likely to be ordered next. The machine presents a variety of autonomous features: it can administrate its revenues, order coffee, and rewards people for helping with its maintenance, e.g. by refilling coffee beans, filling its water tank, and cleaning it.

Bitbarista attempts to illustrate the complexity of factors involved in coffee supply chains, from production to distribution and purchase, in order to provide users a stronger sense of participation within this process. It suggests that data could enable end consumers to be closer to the source of products, reducing intermediaries, and asking how users would receive this proximity. The autonomy of the machine to purchase coffee and set up prices are central within this context. The machine also indicates that choices are made collectively. It asks how people would react to making choices with this collectivity in mind, while placing choices in the future rather than the present. Although the machine only purports to browse data in real time, and the data that it claims to have found is not fully available at that precise moment, its categories were defined based on recent technical reports on coffee production, and the process that it illustrates is not far-fetched. Our motivation was to design a connected device that would provide a more positive attitude towards data display, usage and sharing.

Bitbarista is different from most IoT devices in the sense that:

A) It displays rather than conceals data processes;

B) It connects data to the situation experienced, placing users within the forces that govern this data; and

C) It offers options for users to choose how they would like to participate within this process.

What are the implications for Design?

Bitbarista is a prototype device that proposes a new approach to data access and usage for the design of IoT devices. Rather than focusing on ease-of-use, Bitbarista focuses on revealing data transactions, attempting to

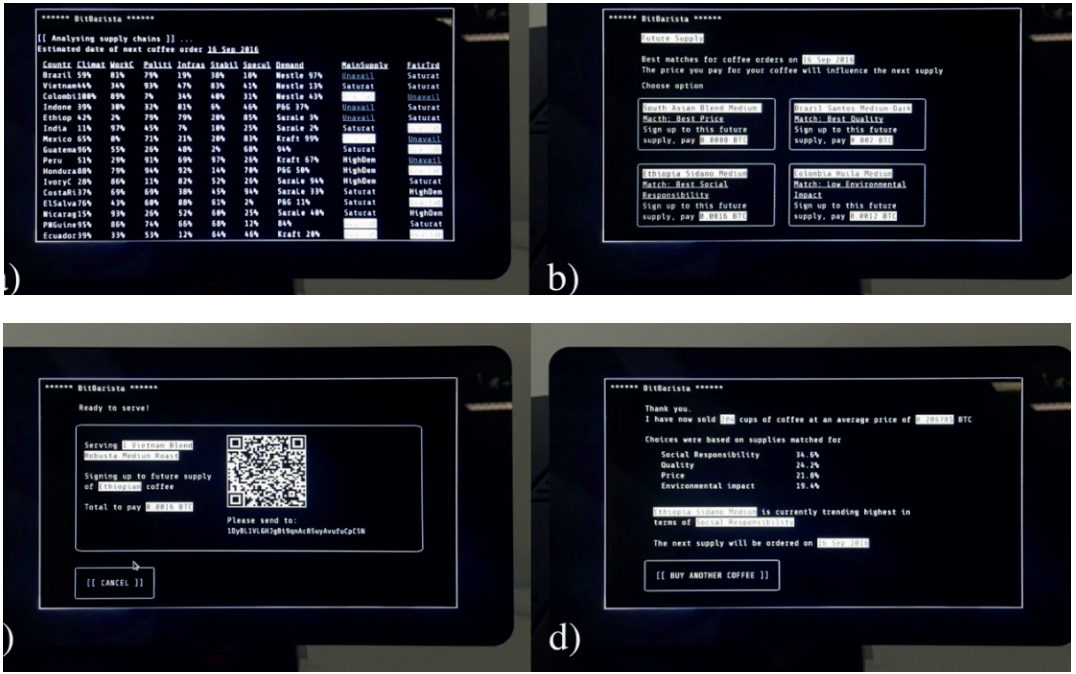


Figure 12. Bitbarista a) Analysing data on the state of coffee producing countries; b) Narrowing down results to four options; c) Selling coffee for bitcoin contribution towards next supply; d) Situating choice within the pool of choices previously made beforehand.

communicate and place users within the complexity of factors involved in coffee production, distribution and purchase. Through working with participants, we found that they were more comfortable about data gathering that was perceived as relevant for the interaction taking place. Bitbarista, however, expands the notion of what is relevant, by placing participants within a broader context of production and consumption. Responses to the study suggests that despite usual discomfort, participants were happy to share data as it was perceived to be for a good cause. However, in the face of current practices of data gathering and sharing, this trust is not easy to achieve. Interview responses suggest that participants are weary of data gathering taking place in opaque or secretive ways. Increasing transparency of data transactions, as Bitbarista does, is, therefore, a good step forward. Based on these insights, we identified a few design implications as discussed below.

The main design implication taken from the Bitbarista project is to highlight how communicating the complexity of transactions and the reasons for these transactions to occur can have a positive impact on how users perceive an IoT system.

This includes:

A) Communicating what kind of data is gathered from users and making it absolutely clear when no data is gathered. A non-data gathering convention or certificate would be something to be considered in this case.

B) Allowing people to understand the model of value creation behind the system. The Internet of Things opens space for new models to be created that do not necessarily fit usual assumptions of linear chains of value connected to monetary transactions. Designers should focus on designing systems and interfaces that embody and communicate these new value propositions.

C) Allowing machine-made decisions to be questioned and personalisation to be constantly tailored by users. While automatisation and concealment of transactions may facilitate ease of use, inviting people to follow and go back in this process in order to tailor its parameters may increase trust. Perhaps it is time to make a case for interfaces that increase complexity and time

of use, even displaying information that is “rarely needed”.

In our final case study we introduce a workshop method that enables people to design simple value constellations in the street, through the use of smart contracts.

3. Geocoin

by Bettina Nissen, Larissa Pschetz, Dave Murray-Rust, Shaune Oosthuizen and Chris Speed from the Centre for Design Informatics, University of Edinburgh and Hadi Mehrpouya from Abertay Dundee University

Designers and 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. GeoCoin is a location-based platform for experiencing and ideating with smart contracts (Nissen et al 2018). 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.

Smart Contracts

New complex infrastructures, such as programmable currencies, distributed ledger technologies and smart contracts, are becoming increasingly widespread. These infrastructures support many finance and distribution transactions, often running in the background of larger applications away from the users’ awareness. There is an increasing list of applications and proposals to employ blockchain technologies in the context of the Internet of Things which extends from the Smart Home into the Smart City, and is bound to result in wide-reaching implications for users, consumers and citizens alike.

Figure 13. Participants setting off and exploring GeoCoin

Remaining in the background of users' experiences, awareness of these technologies is often mediated by technological narratives. Although many have now heard of cryptocurrencies or blockchain, public understanding is shaped by partisan narratives of the future, whether utopian or dystopian, decontextualized and echoed in the mainstream media. In media reports, these technologies are ready to replace governments, democratize the Internet, or are Ponzi schemes to scam the gullible and to support illicit activities.[2] 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.

[2] Some examples of recent media headlines about cryptocurrencies can be seen in the following:

"IMF Issues Stark Warning Over Bitcoin And Crypto 'Rapid' Growth" Forbes, Oct 2018;

"Bitcoin buyer beware: US SEC warns 'extreme caution' over cryptocurrency investments" Guardian, Dec 2017;

"Economist who predicted financial crash warns Bitcoin is 'mother of all scams'" The Telegraph, Oct 2018;

"Shark Tank stars warn of bitcoin scam" Daily Mail, April 2018;

"Bank of England chief Mark Carney says only 'fools' are investing in Bitcoin" Daily Mail, March 2018.

GeoCoin was developed as a platform that aims to facilitate understanding and ideation with location-based smart contracts, self-executing computer protocols that run on distributed ledgers (e.g. Ethereum or Bitcoin Blockchain). Geo-Coin provides a grounded experience of smart contract infrastructures, while remaining open for exploration, reuse, and final translation into new deployments, offering participants the grounding to develop their own perspectives not solely limited by media portrayals of technological innovations. The use of location-based contracts is intended to contextualise the technology in everyday practices.

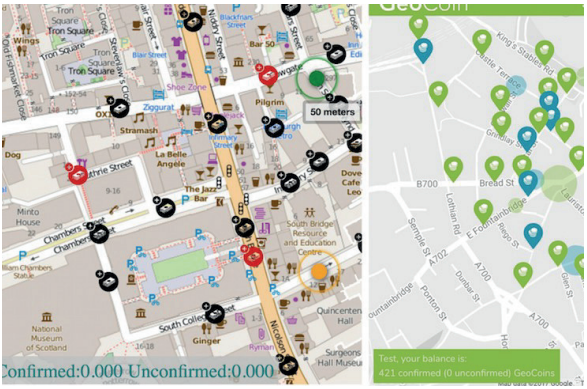


Figure 14. First iteration of GeoCoin (left) and second iteration (right), showing single use transaction pins and continuous transaction zones.

The Geocoin App

GeoCoin is an explorative platform for location-based, or geo-fenced currencies which allows researchers and designers to engage wider audiences in understanding and designing with novel infrastructures of smart contracts and cryptocurrencies. Smart contracts are attached to physical locations, and participants interact with them using a smartphone app that shows the contracts on a map as they 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.

In the initial setup, there are two types of smart contract: i) Debit/credit coins perform a single transaction with the first participant who comes within the radius of the contract; ii) Debit/credit zones continually add or remove currency from all participants within their radius. Figure 14 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. These zones can be easily administered through a web interface (Figure 15), allowing workshop organisers and designers to quickly establish new experiences alongside participants.

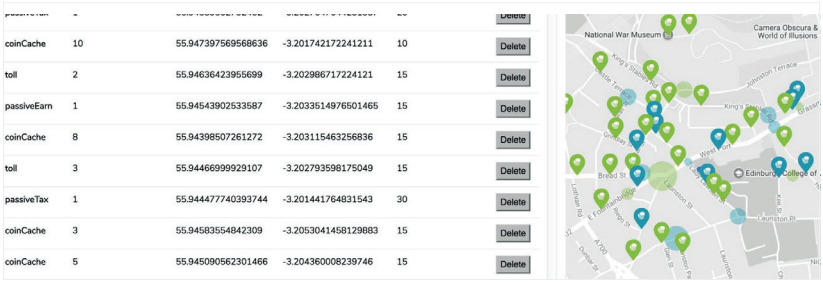


Figure 15. GeoCoin admin panel in final iteration.

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 standalone 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, industry experts, informatics students, community groups, creative industry organisations, artists and designers. Overall, we offered four workshops with participant numbers ranging from eight 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 and were

documented using post-it notes, audio, video recordings and field notes. Each workshop followed a similar three 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 (2015) session which helps people understand Blockchain technologies.

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 transform their ideas into new forms of smart contract applications. After a code sprint, the prototypes were then collectively experienced.

Participants' Projects

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 with the ethos or promise of distributed ledger technology. The projects included creating novel, cause-specific currencies, gamified incentive smart contracts and distributed budgeting systems, and often had a playful and creative feature. Suggestions included gamifying a city's tourist attractions to alleviate crowded hotspots and increase visits to lesser known cultural venues; counteracting gentrification by offering residents the chance to build

Figure 16. Participants mapping GeoCoin opportunities and implications.

community equity; and a new cultural currency that could only be spent at cultural events and venues in the community. To further showcase the value and use of GeoCoin in the shared ideation process of participants, we have selected three main designs that were the direct result of participants' interaction with GeoCoin during our workshops.

1. *Handfastr – Making Commitments Wherever You Are* by Corina Angheloiu, Max Dovey and James Stewart

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 three 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 17). 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.

Figure 17. A Bitcoin marriage in Finsbury Park, 2017

2. *Civic Blocks – Participatory Budgeting with Bitcoin* by Dorota Kamrowska-Zaluska, Hanna Obracht-Prondzynska and Eileen Wagner

How can we use new technologies to create a more democratic city? How can we involve citizens in decisions about 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 18). The system empowers local residents to actively take part in shaping their civic community, while creating a transparent and fair platform for participatory budgeting.

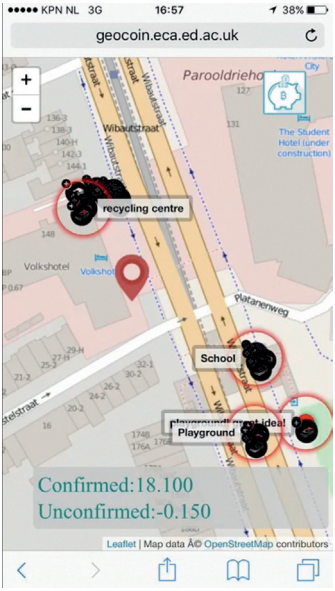


Figure 18. Screen capture of real-time participatory budgeting using Civic Blocks

3. *GeoAid - Distributing Humanitarian Aid Directly* by Bettina Nissen, Kate Symons and Shaune Oosthuizen

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 establish a fund for a stated purpose in a particular location. The public could then donate money

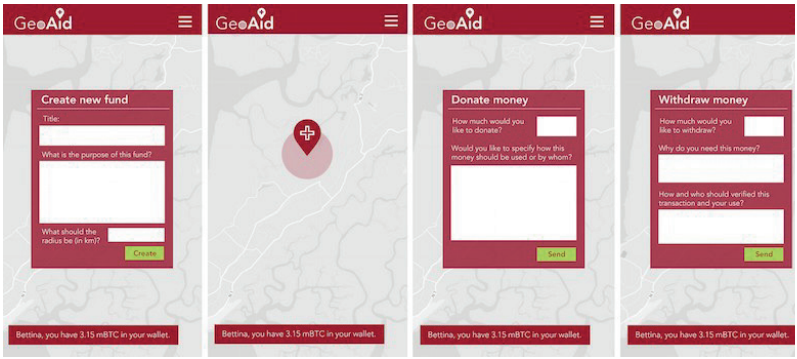


Figure 19. GeoAid iteration of GeoCoin by researchers.

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 19) 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.

Summary

GeoCoin is aimed at creating a shared environment for speculative ideating and collaborative designing with location- based smart contracts. The primary successes of GeoCoin are:

1. Make smart contracts experientially accessible to non- specialists.
2. Explore values and concerns of smart contracts for smart cities.
3. Allow participants to ideate with smart contracts.

GeoCoin is freely available as a platform for creating open geo-located smart contract experiences.

Conclusions

Creating value for a new and yet to be explored technology, such as IoT, is a significant challenge for designers who have been employed to add value in traditional value chains. Due to their constant connection to the internet products are better understood to be services, and data is not a natural material for designers to work with. However, understanding user needs and behaviour is fundamental in value creation for an emerging technology and designers have specialist skills in understanding users' needs in order to mediate value. These skills, that have been developed over several decades, offer designerly ways that will prove to be crucial within the entire design and development process for IoT.

Having briefly introduced these three short examples of the development and implementation of IoT products, services and systems in operation, we can see the profound implications that effect the practice of design. Due to the fast-moving nature of data-driven flows and real-time user interactions, the designer needs to adopt a strongly proactive approach to the creation of meaningful 'experiences', which if choreographed effectively, can add real value to the user. Design implications for practice set against an IoT background, feature five key aspects of consideration gleaned from the cases:

1) *Design 'Agility'* whereby the design team needs to be prepared to work within iterative, development cycles that involve scanning and interpreting real-time data flows to 'build, measure and learn' how value is operating within an ecosystem. These skills and methods will lead to the development of sensibilities that will help the creation of new products and services opportunities that operate across value constellations.

2) *Design 'Inclusivity'* in such a way as to acknowledge all of the social, cultural and economic actors who are involved in a value constellation (including the non-human things). The design imperative here is being aware of the flow of value across a value

constellation so that you can offer adaptable services. This will involve being unafraid of adopting new novel approaches to prototyping and testing the system with all the related actors within a constellation.

3) *Design 'Divergence'* enables and supports the ways of seeing, understanding and defining problems and subsequent opportunities through a wide range of esoteric perspectives. In essence, the rise of IoT has made traditional and long held design orthodoxies redundant within contemporary industry practice. In order to remain relevant, the designer needs to develop new and dynamic practices that reflect and respond to fluid opportunities that may arise.

4) *Design 'Devotion'* demands the ability to take an initial opportunity and transform it into a cohesive but yet highly flexible design brief. This may entail the need to move beyond established design boundaries and seek the advice and support of experts operating into related and complementary fields of practice adjacent to IoT development. Often problems seem unsurmountable at first, but through collaboration with complementary disciplines, these problems could be overcome leading to innovative commercial opportunities in the long run.

5) *Design 'Entropy'* and the confidence to thrive on uncertainty and ambiguity. IoT practice is located within a creative and dynamic process with long completion times where real-time data and multi-stakeholder input can lead multiple value propositions. If this can be successfully negotiated and achieved, a wider contextual framework for subsequent IoT introductions could lead to new applications beyond their original remit(s).

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