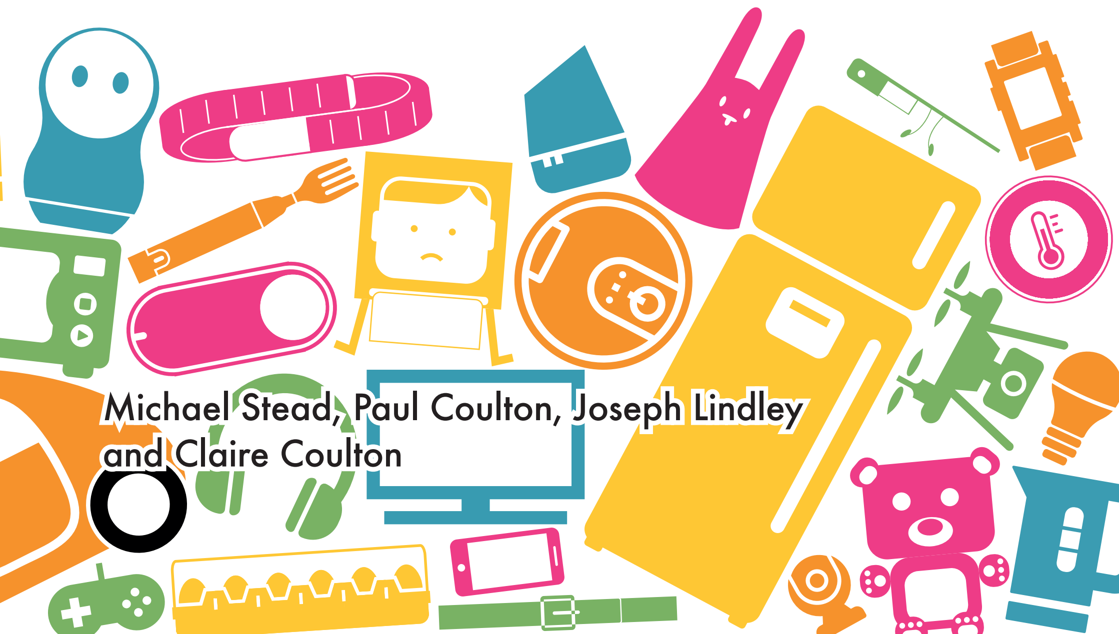
The Little Book of SUSTAINABILITY for the Internet of Things



Michael Stead, Paul Coulton, Joseph Lindley and Claire Coulton

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

ISBN 978-1-86220-360-0

The Little Book of SUSTAINABILITY for the Internet of Things

Michael Stead, Paul Coulton, Joseph Lindley and Claire Coulton

Acknowledgements

This book is based on our research conducted for the PETRAS Cybersecurity of the Internet of Things Research Hub funded by the UK Engineering and Physical Sciences Research Council under grant EP/N02334X/1. The aim of PETRAS is to explore critical issues in privacy, ethics, trust, reliability, acceptability, and security and is undertaken by researchers from University College London, Imperial College London, Lancaster University, University of Oxford, University of Warwick, Cardiff University, University of Edinburgh, University of Southampton, University of Surrey, Newcastle University and the University of Bristol.

For their support in creating this book, many thanks to Rachel Cooper and Samantha Ward.

We would also like to say thank you to Bruce Sterling as without his fascinating and provocative book *Shaping Things*, we would not have been inspired to carry out this body of research.

Contents

What this little book tells you

There are numerous loud and powerful voices promoting the Internet of Things (IoT) as a catalyst for changing many aspects of our lives for the better. Think healthcare, energy, transport, finance, entertainment and in the home – billions of everyday objects across all sorts of sectors are being connected to the Internet to generate data so that we can make quicker and more efficient decisions about many facets of our lives. But is this technological development completely benign? Despite all their positive potential, IoT devices are still being designed, manufactured and disposed of in the same manner that most other 'non-connected' consumer products have been for decades – *unsustainably*. Furthermore, little of the discourse around the IoT recognises or responds to this growing issue. We hope this Little Book will kickstart this important conversation and help those creating future IoT products and services to consider new approaches that have sustainability *baked-in*. Further, we propose the re-characterising of IoT objects as *spimes*[1] to provide an alternative approach for enabling sustainable IoT device design. Spimes are a potential class of internet-connected objects which, unlike present day IoT devices, would be designed such that they can be managed sustainably throughout their entire lifecycle, from their initial design and production, to having their components recycled and reused at the end of their life.

Drawing upon our practice-led design research, we begin this book by explaining the relationship between sustainability and the IoT, and discuss some of the main approaches to sustainable design that have informed this research. Subsequently, we discuss the value of the spime approach and its potential impact. Finally, we illustrate how we might design spimes by using *Design Fiction* to present three examples of spime design, each of which explore different desirable design criteria for spime objects, while also highlighting the broader implications of adopting them:

- The *Toaster for Life* study examines how spimes could affect connected product business models and user behaviour.

[1] Bruce Sterling, 2005, *Shaping Things*, Cambridge: MIT Press.

- *HealthBand* shows how spimes might impact product design policy through the democratisation of design-innovation practices.

- *The Future Is Metahistory* investigates what spimes would mean for digital ethics and data ownership.

In summing up, we present *spimes as a multidimensional lens* which we hope other researchers and developers of future IoT products and services can harness to envision a more sustainable connected future.

Introduction

Overpopulation, mass consumption, unprecedented waste – the threat to the ongoing sustainability of our planet has never been more profound. Yet, the issue of sustainability is vast, complex, and oftentimes intangible. It can be hard to know how to begin to tackle environmental issues, either from an individual, societal, designerly or technological standpoint. Sweeping terms such as 'climate change', 'global warming' and 'carbon emissions' are used to describe the problems affecting sustainability, but they are not always helpful in bringing about a wider understanding of the substantial issues facing the planet. Tellingly, the task of returning earth to a sustainable equilibrium is often characterised as a 'wicked problem',[2] meaning that unsustainable systems, lifestyles and devices have now become so entrenched throughout modern societies that they probably cannot ever be fully countered. One might reasonably ask then, why bother to keep trying to make our world more sustainable? As designers, we take the stance that, while completely reversing the unsustainable quagmire we now find ourselves in may be a near impossible task, this does not mean we should not try to reframe our design practices so that we no longer continue to develop unsustainable products and services.

Buckminster Fuller, the famed 20th century designer, architect, futurist and *environmentalist*, used the metaphor of earth being a huge spaceship travelling through space. He argued that the earth (like a spaceship) has a finite amount of resources that needs continual maintenance in order to function properly and stay on course.[3] We share this view, that due to its complex nature, planetary sustainability should be seen as more of a process to be *effectively managed* as opposed to being a problem to be *outright solved*. This perspective provides the foundation for the research

[2] Horst W. J. Rittel and Melvin M. Webber, 1973, *Dilemmas in a General Theory of Planning*, Policy Sciences. 4: 155–169. DOI:10.1007/bf01405730

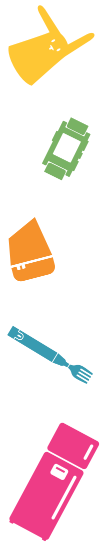
[3] R. Buckminster Fuller, 1968, *Operating Manual for Spaceship Earth*. An online copy is available here https://web.archive.org/web/20100717141812/http://bfi.org/about-bucky/resources/books/operating-manual-spaceship-earth

discussed in this Little Book which focusses on the role that sustainability can potentially play in the design of future IoT products. Put simply, the IoT is the idea that anything, and potentially everything, can be connected to the Internet.[4] Recent years have seen the types of connected objects evolve from traditional screen based devices like desktop computers and laptops, through phones and tablets, into a wide variety of 'things' including fridges, vacuum cleaners, wearable fitness trackers, cars and lighting. The notion that computation and connectivity will be made to be omnipresent and available anywhere, at any time, using any physical device, is already being seen to have both major advantages and disadvantages for society. Whilst the vast majority of IoT discourse focuses on the economic opportunities for the creation of new products and services, others have considered the negative impacts of this expanding paradigm. Through his notion of *everyware*, Adam Greenfield critiqued the impacts of widespread, embedded computation on peoples' privacy and social liberty,[5] whilst Bruce Sterling coined the term *spimes* as a way of considering the possible environmental implications arising from the unbridled pursuit of the economic potential of the IoT by the design industry, product manufacturers and technology firms. In light of the unsustainability of the vast majority of current IoT devices, the highly provocative spimes concept appears ripe to be developed as a new approach for sustainable design in the IoT era.

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

[5] Adam Greenfield, 2006, *Everyware: The Dawning Age of Ubiquitous Computing*, Berkeley: New Riders.

What is Sustainable Design?



The discourses that surround sustainability are multi-layered, which means it can easily become confusing. That said, from now on, when we refer to ‘sustainability’, we do so in the context of manufactured consumer IoT devices, specifically, what effect the lifespan of such devices – including the design, production, consumption and disposal stages – has on the natural environment. While the IoT is still a relatively new paradigm, the idea that consumer devices should be designed and manufactured with environmental sustainability in mind has been around for decades. This is primarily because industrial product design culture has long relied upon mass production, product iteration strategies and *planned obsolescence*[6] to increase profits and market share. Many commentators argue that these factors, when coupled with population growth, aging societies and increasing urbanisation, have had a profoundly negative effect on environmental sustainability for the best part of 75 years.[7] During this period, many different sustainable design strategies have been proposed to minimise the environmental effects caused by disposable manufactured consumer devices. We cannot outline all such approaches, so instead, we

[6] In *The Wastemakers* (1967), Vance Packard characterises *planned obsolescence* as a combination of both *obsolescence of function*, where a product is designed to purposely fail to significantly shorten its lifespan, and *obsolescence of desirability*, where advertising and fashion trends are used to ‘psychologically outmode’ existing products.

[7] Tony Fry’s *Design Futuring: Sustainability, Ethics & New Practice* (2009) and Giles Slade’s *Made to Break: Technology and Obsolescence in America* (2007) are good starting points.

provide a short overview of the key sustainable design thinkers and strategies that have underpinned our research:

- Victor Papanek was one of the first to urge product designers to take greater responsibility for their work and create practical solutions to societal problems as opposed to focusing on product aesthetics and the creation of superfluous gadgetry.[8]
- Vance Packard attributed modern society's propensity to over-consume to designers' use of planned obsolescence. Packard reasoned that while obsolescence increases profits, it comes at the cost of excess waste.
- Currently, 90% of electronic items reach landfill in their whole form. Whilst *Design for Disassembly* (DfD) aims to counteract this by incorporating opportunities for user maintenance, component substitution and efficient disassembly when a device is no longer needed, it is rarely utilised as a design practice.[9]
- *Life-cycle Assessment* (LCA) is a technique designers' can use to holistically evaluate the environmental impacts associated with every stage of a product's existence. LCAs can take two forms – an *Attributional LCA* is where the assessment is made *before* a product is put into production, while a *Consequential LCA*, as the name suggests, is carried out *after* a device has reached the end of its life.[10]
- The term *circular economy* describes a socio-technical system which seeks to minimise the use of key inputs like materials and energy, as well as reduce outputs including harmful waste and carbon emissions. Proponents argue that this can be achieved through 'closed loops' – where inputted resources are continually preserved and re-appropriated within the production cycle.[11]

[8] Victor Papanek, 1971, *Design For The Real World*, St Albarns: Paladin.

[9] Alex Diener, 2010, *Afterlife: An Essential Guide To Design For Disassembly*, https://www.core77.com/posts/15799/afterlife-an-essential-guide-to-design-for-disassembly-by-alex-diener-15799

[10] Nathan Shedroff, 2009, *Design Is the Problem: The Future of Design Must Be Sustainable*, New York: Rosenfeld.

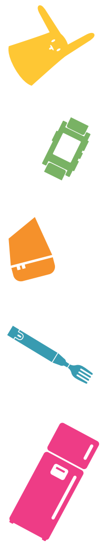
[11] Ken Webster, 2015, *The Circular Economy: A Wealth of Flows*, London: Ellen MacArthur Foundation Publishing.

- Michael Braungart & William McDonough contend that traditional notions of 'reduce, reuse & recycle' are fundamentally ineffective. They argue that a device should be designed so that it can easily be separated at the end of its life into *biological nutrients* – natural, biodegradable components – and *technical nutrients* – materials that retain their quality and capabilities. This *Cradle to Cradle* model limits valuable materials becoming degraded, contaminated or lost to landfill.[12]

Through our research, we have concluded that the majority of current approaches to designing IoT devices simply perpetuate the unsustainable design culture that the above strategies have long sought to redress. In the next section, we explain in more detail, why and how IoT design culture negatively affects sustainability.

[12] Michael Braungart and William McDonough, 2008, *Cradle To Cradle: Remaking The Way We Make Things*, London: Vintage.

Why are many IoT devices unsustainable?



From a sustainable perspective, much fanfare is made about how adoption of the IoT can help reduce peoples' energy usage and carbon footprint. This 'smart narrative'[13] is clearly evident in the way commercial IoT product-services like the *Google* owned *Nest smart thermostat* and *British Gas' Hive* connected heating platform are marketed. Such rhetoric also runs through the British Government's mission to roll-out smart meters to 80% of UK homes by 2020.[14] Crucially, amidst all this hyperbole, the unsustainability of the 'things' themselves is largely ignored.

Made from cheap, easily breakable materials, IoT product lifespans are designed to be brief. Their design does not incorporate means for repair, upgrade or recycling. So when new generations of IoT devices are released with better functionality, software and aesthetics, the old products become redundant, and, more often than not, will end up as electronic waste in landfill with their precious materials and *embodied energy*[15] forever lost. This inherent disposability is compounded by IoT design culture's preference for developing decadent and unnecessary 'gizmo' style devices.

[13] Yolande Strengers, 2013, *Smart Energy Technologies In Everyday Life: Smart Utopia?*, Basingstoke: Palgrave Macmillan.

[14] GOV.UK, 2013, *Smart Meters: A Guide*, https://www.gov.uk/guidance/smart-meters-how-they-work

[15] *Embodied energy* is the term given to the total estimated sum of energy that will be required for a manufactured object's entire lifespan.

Self-driving baby strollers, connected egg boxes, smart underwear[16] - we suggest many such IoT gizmos 'solve' problems that do not really exist. It seems that under a façade of innovation, IoT designers and technologists are so preoccupied with producing and commercialising connected objects - that they do not stop to consider the lasting environmental damage resulting from such devices.

The growing availability and affordability of disposable connected devices is evidence that commercial entities also view the IoT as primarily a profit making enterprise. Such companies do this principally in two ways: firstly, by selling physical manufactured devices in which computational capabilities (e.g. software, sensors and actuators) are embedded; and secondly, by harvesting and monitising users' personal digital data that is generated during the use of said devices.[17] This two-pronged business model often ties consumers to *iterative physical-digital ecosystems*[18] and has led firms that were once solely online platforms such as *Google*, to start manufacturing physical connected products (e.g. the *Pixel* phone and *Home* smart speaker) in order to colonise the market.

As a response to the IoT's inherent unsustainability and its incessant focus on novelty and monetisation, we chose to unpack and develop Sterling's *spimes* concept as a counterpoint, specifically one where the core value to be gained from connecting physical artefacts with digital data processes is *sustainable change*.

[16] www.Smartbe.co, 2019; www.quirky.com, 2019; www.Skiin.com, 2019

[17] Jathan Sadowski, 2016, *Companies are making money from our personal data – but at what cost?* https://www.theguardian.com/technology/2016/aug/31/personal-data-corporate-use-google-amazon

[18] The connectivity of the IoT is changing the relationship between producers and customers. After being purchased, a physical IoT device, and, by extension its user, remains tied to a bigger, evolving ecosystem of digital services, processes and support. For example, through the use of Apple devices like the *Watch* and *HomePod*, users can access Apple's online digital services including *iTunes*, *Apple TV* and *iCloud*. Such platforms, and the user data/content that they 'house', can usually only be accessed through Apple branded products. Like most consumer technology firms, over time Apple will release new iterations of their physical devices as well as conduct upgrades to their to digital services. In order to continue to access their personal content, users are often forced to upgrade their devices in line with these changes. As such they become tied (often unintentionally) to a particular brand's product ecosystem.

What are spimes?

On a practical level, a spime would be a type of near future, internet-connected object, which marries physical and digital elements with sustainable characteristics. Spimes do not actually exist yet, but they could do so in the near future, and given the increasing unsustainability of the IoT, we think now is the right time to explore the idea in greater depth. The concept was first introduced in 2004 by the futurist Bruce Sterling and then outlined further a year later in his book *Shaping Things*. The term is a contraction of the words 'space' and 'time'. Sterling describes spimes as 'material instantiations of an immaterial system... they are designed on screens, fabricated by digital means and precisely tracked through space and time throughout their earthly sojourn'. Unlike the disposable IoT objects of today, spimes would be designed so that they can be managed sustainably throughout their entire lifecycle, from their initial design and production, to having their components recycled and reused at the end of their life. To help us better understand this distinction, Figure 1 shows the differences between the key stages of the *lifespan* of a present day IoT device and the envisioned *lifecycle* of a potential near future spime object. Whereas a current IoT device's lifespan is essentially 'cradle to grave' - it is limited, disposable and unsustainable, a spime's lifecycle would be designed to be 'cradle to cradle' – cyclical, ongoing and *sustainable*.

Spimes are NOT Things but Things ARE definitely Gizmos

In *Shaping Things*, Sterling also notes how the development of new technologies not only influences product design cultures but also has a profound impact upon societies at large. He uses the term *artefacts* to describe the

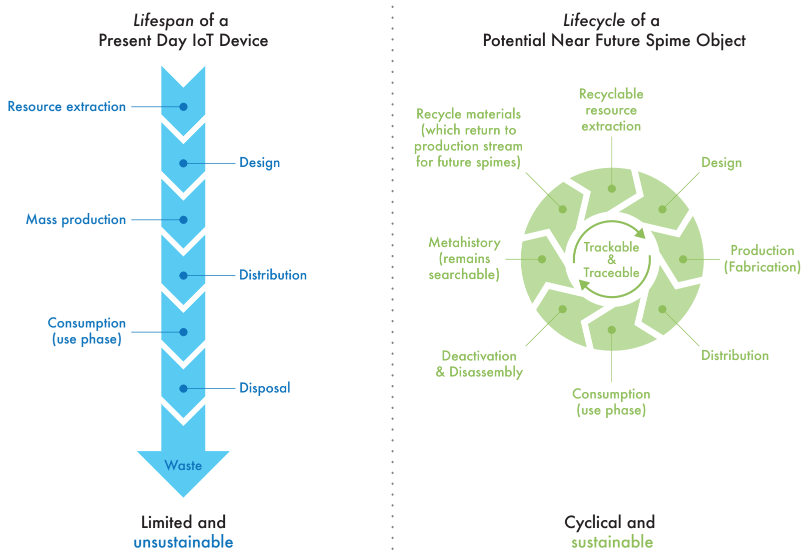


Figure 1. The contrast between the *lifespan* of an IoT device and the envisioned *lifecycle* of a spime object.

first *techno-culture*[19] (circa 2,000,000 BC) and explains that it was characterised by early technologies such as bespoke farmers tools made by hand. The environmental effects caused by the production, consumption and disposal of these early things was miniscule and these processes were more transparent than our experience with today's mass manufactured objects. Back then, people were much closer to the means of production and they made use of natural materials, which could eventually be repurposed or returned to their local ecosystem.

Following *artefacts*, peoples' things evolved over time into a paradigm Sterling terms *gizmos* in which products have computing power embedded within them. As discussed earlier, the IoT is a breeding ground for many gratuitous and disposable products, which are frequently promoted as solutions to real-world problems but these problems are often highly

[19] Sterling determines that there have been four key techno-cultures throughout human history – *artefacts*, *machines*, *products*, and *gizmos*. He argues that the gizmos paradigm began around 1984. We contend that it continues until this day with IoT design culture presently at the forefront.

trivial in nature. Such devices offer little meaningful value for users, other than providing short-term novelty and superfluous functionality. In addition, their lifespan is complex, obscure and unsustainable. We argue that today's IoT devices sit firmly within the gizmos techno-culture and characterise such devices as *unsustainable computerised things designed to have short lifespans*.

Spimes always 'show and tell'

Whilst other researchers have written about spimes, they predominately overlook their sustainable advantages and simply conflate the idea with the IoT, in other words, spimes have oft been characterised merely as internet-connected devices with more advanced tracking and tracing capabilities. In a spime-based paradigm, the prime reason for 'connectivity' would not to be to hook up any and every 'thing' to the internet for the sake of it, or to surreptiously capture and monitise people's personal data. Rather, connectivity would enable spimes that are trackable and traceable throughout their lifecycle for a different value proposition entirely – *sustainable change*. Whereas the 'material instantiation' (the physical, tangible product) of an IoT device is only visible to its user, both material and digital (the data a spime object would generate, both while being operated by its user(s), and through its own accord) instantiations of a spime would be explicit and manageable by its potential users.[20] An individual spime object would always be the sum of its 'parts' - this *dual transparency* would make spimes a greater sustainable proposition than current IoT devices, which are often designed to keep their data processes and digital infrastructures hidden from users as it is generally considered as being not integral to the activities that people use the devices for.

Making both instantiations of spimes explicit could be an effective way of increasing accountability amongst users, helping them to make more responsible decisions in regard to the types of connected products they purchase, how they then use them, and, ultimately, how they go about

[20] This important aspect of spimes is discussed more fully in Michael Stead, Paul Coulton and Joseph Lindley, 2019, *Spimes Not Things: Creating A Design Manifesto for A Sustainable Internet of Things*, in the Proceedings of the European Academy of Design 2019.

disposing of such devices. Similarly, designers and manufacturers would be charged with ensuring all the materials and energy that go into the manufacture and consumption of a spime would not be lost at the end of the device's useful life. So dual transparency, coupled with a focus on product disassembly, and recyclable parts and componentry, would be the principal aspects of a spime object's design specifications.

How do you begin to design Spime Objects?

Although Sterling suggested some possible technologies and features that could be incorporated into a spime's design, he has never attempted to design a spime, nor how people might interact with one. This presents us with the question as to *how might developers of IoT products begin to consider designing spime objects and the likely future world in which they might plausibly exist?* To help provide an answer to this question, we have created a series of *Design Fiction prototypes*[21] that embody a set of *key design criteria* that we identified for spime objects[22] which are:

- *Sustainability* – the prime reason for connecting physical (atoms) with digital (bits) elements, and fundamental to all spime objects.
- *Technology* – the earliest spimes would likely share some of the same technologies we see in today's IoT culture like GPS and RFID but

[21] For a detailed explanation of Design Fiction prototyping, particularly the emerging technique *Design Fiction as World Building*, please see the first book in this PETRAS series, *The Little Book of Design Fiction for the Internet of Things* (2018).

[22] Michael Stead, 2017, *Spimes and Speculative Design: Sustainable Product Futures Today*, Strategic Design Research Journal, https://doi.org/10.4013/sdrj.2017.101.02

instead of being exploited for commercial gain, they would be incorporated into a spime object's design to make it more sustainable.

- *Temporality* – rather than forever staying the same, becoming redundant and eventually ending up as landfill, spime objects would have a lifecycle where they could be changed and updated as often as is required.
- *Synchronicity* – the design and production of connected devices would be more democratic and collaborative, with the required skill-sets and knowledge openly shared for the benefit of communities, as opposed to being restricted to a few corporate entities.
- *Wrangling* – people who develop and use spimes and freely share their design expertise would be called *wranglers*.
- *Metahistory* – a spime device would generate important data about itself throughout its entire lifecycle and this metahistory would be saved and remain searchable, trackable and mineable at any time – *for the benefit of sustainability*.

The following three Design Fiction prototypes use these criteria to demonstrate, both how the design attributes of spime objects would differ from current IoT gizmos, and the implications for a potential future world in which they could plausibly exist.

Prototype 1: *Toaster for Life*

As people often find it difficult to imagine how disruptive technologies and practices can bring about change that is different to their present and past experiences, we decided to first embody the notion of a spime object in the form of a mundane and everyday product, the humble toaster (Figure 2). Whilst household consumer products like smart TVs and smart speakers are some of the most visible and commonplace types of IoT devices that people use today, we felt that redesigning a toaster to be *spime-like* would be a good way to make the sustainable features of a potential spime object appear plausible in an object with no apparent need to be connected to the internet. To make the prototype relatable to peoples' everyday lives,

Figure 2. Sustainable and Internet-connected, the *Toaster for Life*

Figure 3. The product launch catalogue's front cover

we presented the near future spime toaster within its own *product launch catalogue* (Figure 3). We also created a fictional connected product manufacturer and associated branding for the device, as well as giving it a backstory, which outlines reasons behind its development (Figure 4). Importantly, the catalogue also demonstrates how the design and adoption of the new toaster would help combat the increasing problem of connected product waste, which, by 2030, has reached environmentally untenable levels (Figure 5).

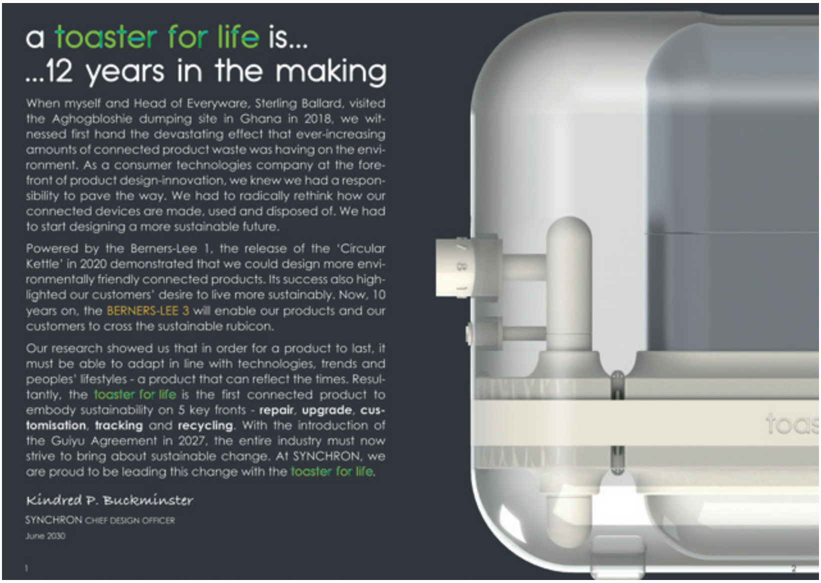


Figure 4. The toaster's fictional backstory

The catalogue pages shown in Figures 6 - 10 detail the five primary sustainable attributes that are fundamental to the spime toaster's design. To incorporate these attributes, we extrapolated of a range of present day IoT technologies and married them with environmentally beneficial possibilities. Within its fictional world, the 'mass produced' toaster's design integrates features which enable its users to effectively repair it, upgrade it, customise it, and recycle it, while all of the device's parts and components are inherently trackable. For example, users could customise the product by 3D printing new parts, the toaster is 90%

Figure 5. The brochure discusses the disposability of most other connected devices

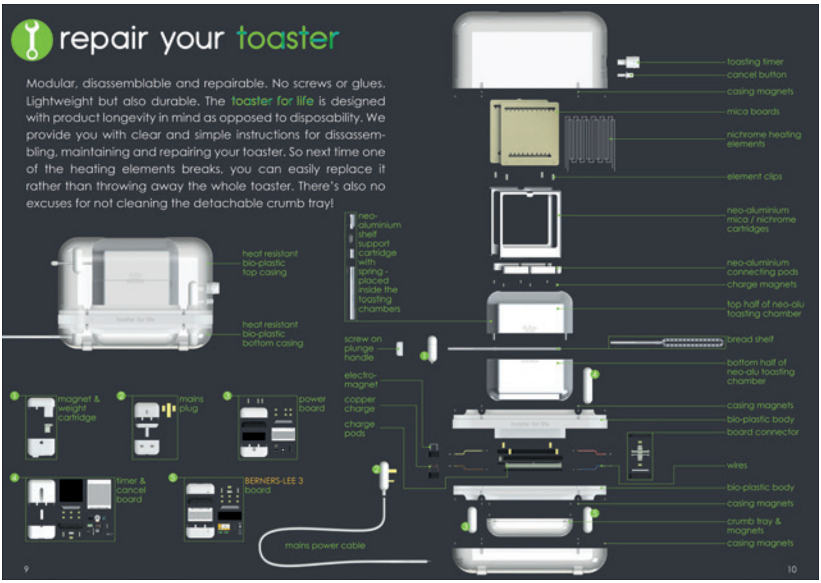


Figure 6. The toaster's modularity enables it be repaired more effectively

Figure 7. Components can be exchanged and reconfigured to allow upgrades

Figure 8. New parts/features can be incorporated through domestic 3D printing

Figure 9. The toaster is made from recyclable 'bio-plastic' and 'neo-aluminium'

Figure 10. Almost every part is 'nano-RFID' tagged making them all trackable

recyclable because it is mostly made from 'neo-aluminium' and 'bio-plastics', and, each of its components are fitted with 'nano-RFID' tags meaning they can be collectively/individually tracked and traced throughout their lifecycle using GPS. We included this range of attributes to ensure that the device's lifecycle is *cyclical, ongoing and sustainable* – hence our choice to name the prototype the *Toaster for Life*. In theory, users would be able to repair and upgrade the device perpetually, customise it to fit every change to their lifestyle, and they would never have to dispose of the product in its entirety as they could recycle parts and replace them with new ones which have also been made from recycled/recyclable materials.

The previous summary begins to demonstrate how the *Toaster for Life* study explores the first three *key design criteria for spime objects* – *sustainability* (through the prototype's range of sustainable features), *technology* (through the extrapolation of various connective technologies), and *temporality* (through the prototype's cyclical lifecycle). We also generated the prototype as a means to provoke questions about how manufacturers might

Figure 11. The *Toaster for Life*'s inherent sustainability would change how its manufacturer provides additional services like product safety, warranty and customer support in more innovative ways.

begin to embrace new cyclical connected product-service relationships with customers – akin to McDonough and Braungart's 'cradle to cradle' model and 'circular economy' thinking – as opposed to continuing to pursue a 'cradle to grave' strategy and allowing *planned obsolescence* to be integrated into their IoT products' lifecycles.[23] We also considered what form a circular connected product relationship between manufacturer and users might take, and how these changes might affect things like product warranty and safety, in the final pages of the *Toaster for Life* launch catalogue (Figure 11).

[23] Michael Stead, 2016, *A Toaster for Life: Using Design Fiction to facilitate discussion on the creation of a Sustainable Internet Of Things*, in the Proceedings of Design Research Society Conference 2016. https://doi.org/10.21606/drs.2016.455

Prototype 2: *HealthBand*

Our second prototype is used to unpack the spime design criteria *synchronicity* and *wrangling*. We did this by exploring the relationship between *decentralised* design innovation activities and the IoT. In recent years, decentralised practices and technologies like open source hardware, crowdfunding and the maker movement have increasingly been cited as more environmentally friendly alternatives to the long established *centralised* strategies that currently characterise the IoT.[24] This is primarily because decentralised products are usually designed for specific purposes in short production runs which cuts out the huge environmental impacts that result from mass manufactured and widely distributed devices. To develop a spime prototype which embodies decentralised principles, we chose to frame our design as a Do-It-Yourself (DIY) medical wearable device called *HealthBand*. Like the 'spime toaster', we thought a spime-like wearable would be another type of IoT product that people would readily identify with given the popularity of fitness and activity trackers from brands like *FitBit* and *Garmin*.

Akin to the *Toaster for Life*, we initially generated a 3D design for the *HealthBand* device. Figure 12 shows the three variations that we created – a diabetes monitor, a dementia memory aid and a Parkinson's stabiliser.

Figure 12. The three variations of the *HealthBand* Do-It-Yourself medical wearable device (right) and a patient wearing the dementia memory aid module (left).

[24] Cindy Kohtala and Sampsa Hyysalo, 2015, *Anticipated Environmental Sustainability of Personal Fabrication, Journal of Cleaner Production*, 99, 333–344.

Mimicking sites like *KickStarter*, *Fundable* and *Indiegogo*, we framed the spime wearable within a fictional online crowdfunding campaign. Figure 13 introduces 'Gary', the main protagonist of the campaign, and outlines his reasons for developing a DIY medical wearable. Against an increasingly privatised UK health service and exorbitant treatment costs, Gary and his friend Phil started to develop *HealthBand* to help manage his young cousin's Type 1 diabetes. Alongside the reduction in size of components, the internet has made digital technologies like open source electronics highly accessible and cheap to buy. Consequently, the last decade has witnessed a growth in 'ordinary people' getting involved in physical-digital 'making' practices. Such activities have been termed *democratised innovation*.[25] Figure 14 depicts the positive response Gary and Phil received when they uploaded their DIY diabetes monitor to a crowdfunding site called *LightBulb*, while we also produced a fictional timeline for the campaign (Figure 15).

Figure 13. Within the fictional world, 'ordinary people' like Gary and Phil use digital technologies such as open source electronics and 3D printing to develop socially beneficial connected devices

[25] Eric von Hippel, 2005, *Democratizing Innovation*, Cambridge: MIT.

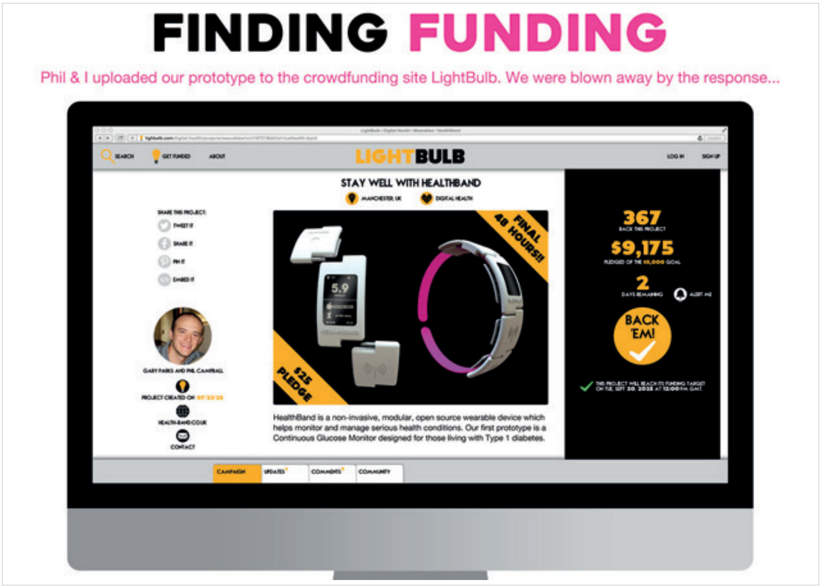


Figure 14. To explore the relationship between spimes and decentralised social innovation, we framed the development of the *HealthBand* device as an online crowdfunding campaign.

Lending plausibility to the prototype's design, Figure 16 details some of the wearable's technical features, in particular its modularity, which means new modules with new functionality can easily be integrated as and when they are developed by other people. We also created a set of *developer's stories* as a way to personify the spime design criteria *wrangling* (Figure 17). The 'stories' outline why and how, in addition to Gary and Phil's diabetes monitor, 'Alicia' (in Williamsburg, New York) and 'Emi' (in Kanto, Tokyo) developed the dementia memory aid and Parkinson's hand stabiliser respectively. The wranglers have each produced and shared their connected devices in an altruistic manner through decentralised networks rather than for monetary gain via conventional corporate, centralised channels.

Having generated the campaign imagery, we broadened the prototype within a more fully rounded *world* as opposed to merely within a narrow 'story' or narrative. To do this, we produced several other related artefacts that provide extra 'points of entry' for audiences to engage with the fictional world. Figure 18 depicts an excerpt from a UK government near future

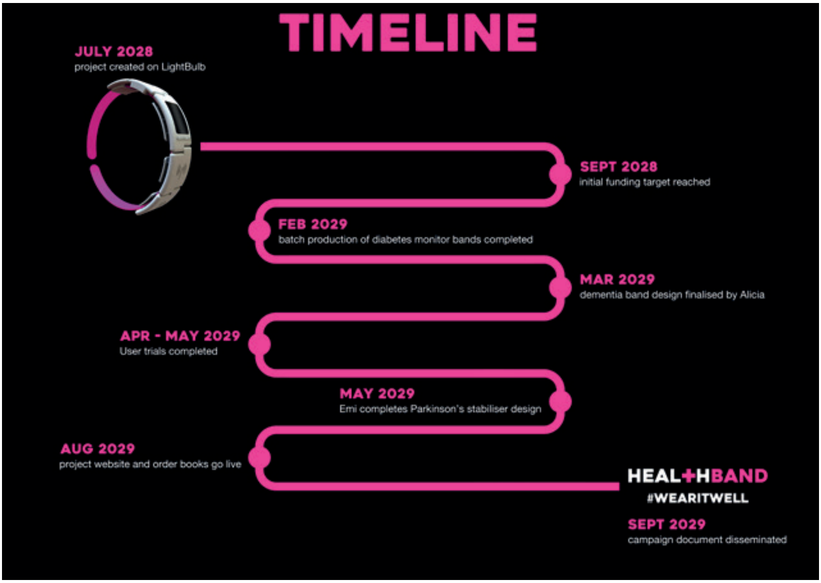
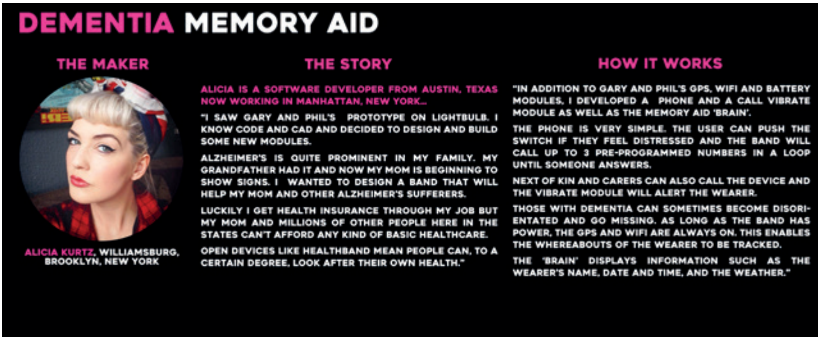


Figure 15. The fictional timeline for the crowdfunding campaign

Figure 16. Modularity would enable new functionality to be incorporated into the device as new modules are developed, while the ergonomics of the pink 'snap on' band means *HealthBand* could easily be used by a wide demographic of users.

white paper we created entitled 'Legislating Do-It-Yourself Wearable Health Devices.' We also thought that any future legislation would still have to be regulated in some way. While DIY medical device production has become legalised within the fictional world, people who wish to develop these products would need to have a valid permit to do so (Figure 19). Similarly, the UK's National Health Service would have to adapt to future changes and



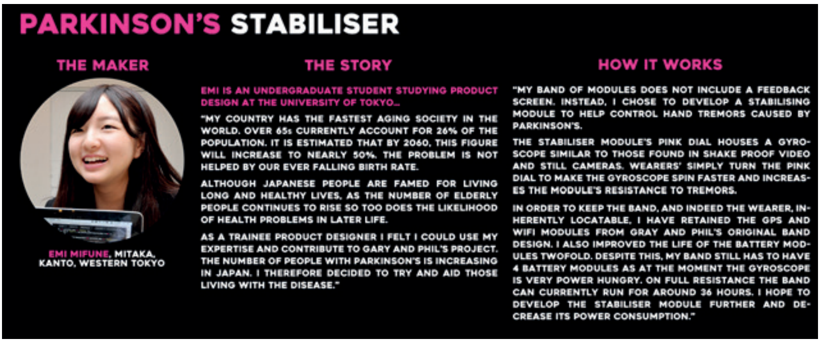


Figure 17. The three *HealthBand* module developer stories

issue guidelines to patients to ensure they develop clinically safe DIY wearables (Figure 20). Once a DIY device have been trialed and met the required performative and safety standards, *wranglers* would be able to share them with people that would benefit from them. Figure 21 depicts a screenshot of a mobile app developed for *HealthBand* as an effective way to convey personal health data generated by the device to its users.

Today, healthcare providers are actively trying to integrate wearables into frontline services because trials have shown such devices are effective in empowering patients' to manage their own care while also reducing demand on medical services and staff. Despite this, the regulatory journey to enable a device to be used by patients is complex and oft protracted due to strict legislation. Health policy decision makers and medical bodies are, quite rightly, cautious to only allow safe and reliable wearables onto the wrists of infirm and elderly patients.[26]

22 Legislating 'Do-It-Yourself' Wearable Health Devices

Department of Health

The case for change

1.1 Rising aging populations living with chronic health conditions like diabetes, dementia and Parkinson's disease have put an incessant strain on the NDHS. Although it has been proven that these conditions can be successfully managed by patients using wearable health devices, due to abstruse health product legislation, too few devices have been made available to patients over the last decade. At the end of January 2027, 345 of the 418 local health authorities had put forward 'autonomous patient digital health' policies for consultation. Since then, the National Digital Health Framework has also published its report on 'home-made' wearable health devices,[20] as a means to fulfil the terms of service pledged by the NDHS in 2021.

1.2 Changes to digital health services have remained slow, expensive and bureacratic, with arguments about how many patients will be able to manage their own healthcare autonomously and what level of services are offered

1.4 In response, this chapter sets out our proposals to reform health product legislation as well as identifying sufficient funding and expertise to make the most of the proposed changes; with community involvement to make the best outcomes for both 'autonomous citizens' and those continuing to use limited health services.

1.5 A number of the proposals build on consultantions and reviews conducted over the last year: the report of the Local Health Device Group; consultations on changes to the National Digital Health Framework;[21] frontline service reviews (the results of patient-led care trials at different sites across the country); and the National Patient Wearable Review also provided evidence.[22] The Government has taken account of responses to these consultations in deciding the way forward . A summary of the responses to each consultation is being published alongside this White Paper.

Getting tech in place

Making sure every UK citizen has

Figure 18. A white paper proposing legislating DIY health wearables in the UK

[26] Michael Stead, Paul Coulton and Joseph Lindley, 2018, *Do-It-Yourself Medical Devices: Exploring Their Potential Futures Through Design Fiction*, in the Proceedings of Design Research Society Conference 2018. https://doi.org/10.21606/dma.2018.475

Figure 19. To regulate DIY production, people would need a permit

Figure 20. Health service guidelines to ensure clinically safe DIY device production

The *HeathBand* prototype enables us to generate discussions about how near future, DIY medical devices might become widely adopted through social innovation practices and localised production channels, and what this would mean for current product design policy and associated legislation.

Figure 21. Personal health data could be viewed via an online app

Prototype 3: *The Future Is Metahistory*

For our third prototype, we generated several artefacts that provide audiences with plausible 'points of entry' to a fictional world in which we explore the final spime design criteria, *metahistory*. By focusing on the possible sustainable implications of the data driven 'digital instantiation' of a spime object, *The Future Is Metahistory* study differs from the *Toaster for Life* and *HealthBand* studies whose prototypes and related artefacts primarily embody a spime's physical, 'material instantiation'. In contrast to the way today's Internet platforms acquire, share and mine IoT data for profit, the value of sharing and mining spime metahistories would be *sustainable change*. Figure 22 is a fictional advert for a spime-like clothes iron. We designed this prototype to show the kind of routine data a spime device would likely generate about itself, and grant users' access to,

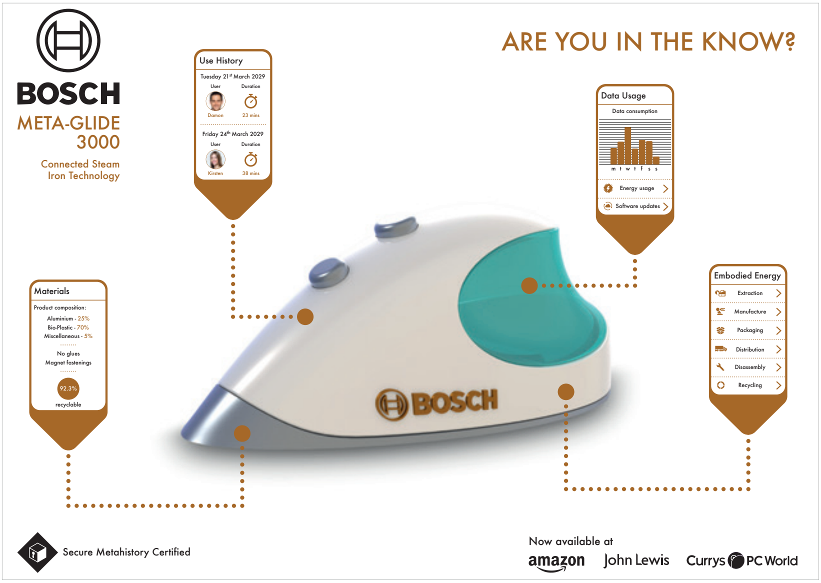
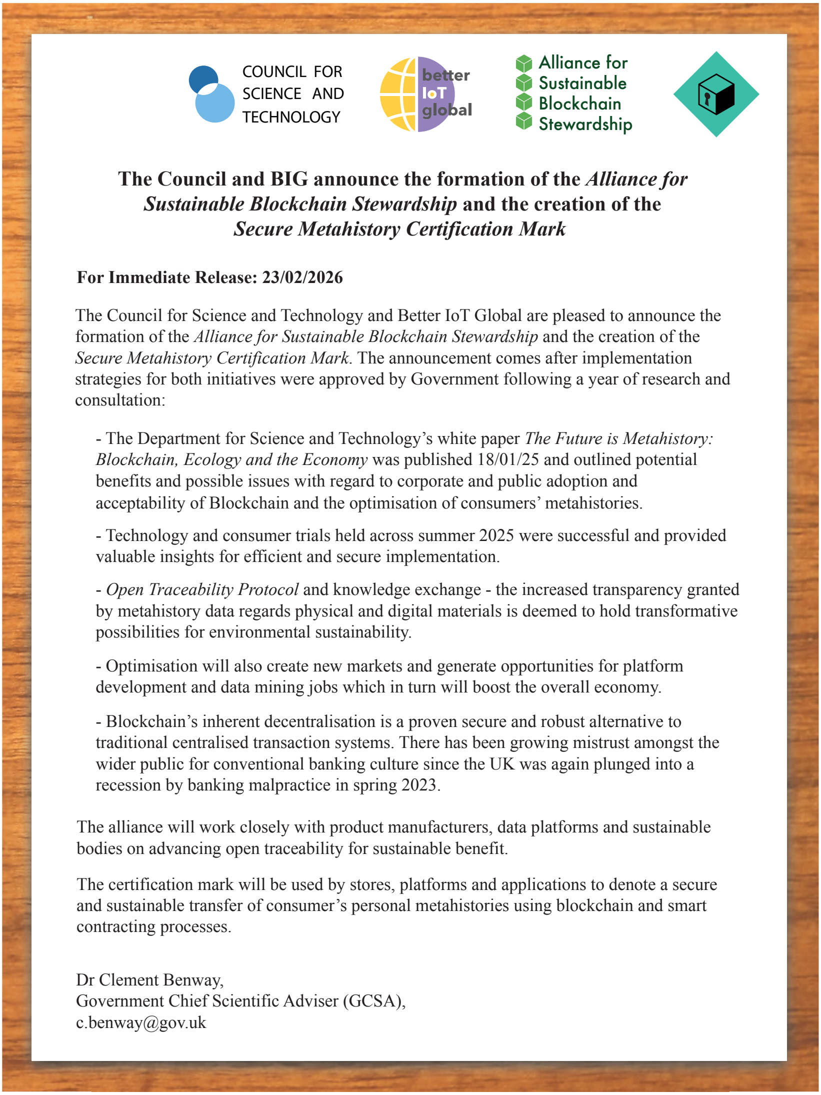


Figure 22. Spime-like devices would generate *metahistory* data which when made accessible to users could facilitate sustainable behaviour.

during its lifecycle. Whereas consumers' currently know very little about the origins of their IoT products, *metahistory data* would make a device's provenance more transparent, for example, by revealing information about the materials the device is manufactured from, the supply chains it has travelled through to market, and its past and current data usage. Metahistory data would also be saved and remain searchable, trackable and mineable by users at any time.

To enable metahistory data collection within our fictional world, we chose to combine it with *blockchain* technology, which is also considered to hold 'transformative possibilities' (Figure 23). A blockchain, in simple terms, is a publicly viewable digital ledger whose secure nature makes it an effective method for managing data transactions between different parties. Blockchains are broadcast across global peer-to-peer networks which typically consist of thousands of computers and servers. Transactions are verified by consensus which means that people on the network confirm any changes between one another. This decentralised process eliminates the need for a centralised certifying authority, such as an established bank or financial broker. Proponents of blockchain argue that it removes bureaucracy, reduces costs and increases the speed of transactions, and most importantly for our prototype, makes data processes *transparent* and *traceable*.

Despite the present day hyperbole surrounding blockchain amongst technologists, it has yet to enter the mainstream consciousness. We therefore created a near future Which? guide (Figure 24) to introduce audiences to the technology and explain its complexities and advantages in terms that can be easily understood. Figure 25 then depicts a mobile app called *Lazarus* which utilises blockchain to facilitate greater 'asset transparency' by tracking the origins and histories of connected products, verifying their provenance and keeping the 'digital instantiation' of the product 'secured' to the 'physical instantiation' of the same product throughout its entire lifecycle. We envisaged an app like *Lazarus* might help to empower sustainable behaviour by helping people to securely recycle, reuse and repurpose data-rich spime objects when they are no longer wanted. Exploring this issue from a commercial perspective, Figure 26 is a receipt for the sale of a second hand spime toaster through the online auction platform *eBay*. As per governmental protocol, *eBay* has included the *Secure Metahistory Certification Mark* on the receipt to denote that this transaction involves blockchain



COUNCIL FOR SCIENCE AND TECHNOLOGY

better IoT global

Alliance for Sustainable Blockchain Stewardship

The Council and BIG announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*

For Immediate Release: 23/02/2026

The Council for Science and Technology and Better IoT Global are pleased to announce the formation of the *Alliance for Sustainable Blockchain Stewardship* and the creation of the *Secure Metahistory Certification Mark*. The announcement comes after implementation strategies for both initiatives were approved by Government following a year of research and consultation:

- The Department for Science and Technology's white paper *The Future is Metahistory: Blockchain, Ecology and the Economy* was published 18/01/25 and outlined potential benefits and possible issues with regard to corporate and public adoption and acceptability of Blockchain and the optimisation of consumers' metahistories.

- Technology and consumer trials held across summer 2025 were successful and provided valuable insights for efficient and secure implementation.

- *Open Traceability Protocol* and knowledge exchange - the increased transparency granted by metahistory data regards physical and digital materials is deemed to hold transformative possibilities for environmental sustainability.

- Optimisation will also create new markets and generate opportunities for platform development and data mining jobs which in turn will boost the overall economy.

- Blockchain's inherent decentralisation is a proven secure and robust alternative to traditional centralised transaction systems. There has been growing mistrust amongst the wider public for conventional banking culture since the UK was again plunged into a recession by banking malpractice in spring 2023.

The alliance will work closely with product manufacturers, data platforms and sustainable bodies on advancing open traceability for sustainable benefit.

The certification mark will be used by stores, platforms and applications to denote a secure and sustainable transfer of consumer's personal metahistories using blockchain and smart contracting processes.

Dr Clement Benway,
Government Chief Scientific Adviser (GCSA),
c.benway@gov.uk

Figure 23. In our fictional world, the transparency of product meta-histories underpinned by blockchain technologies have been identified as having considerable sustainable benefits. This has led the UK Government to implement the 'Open Traceability Protocol'.

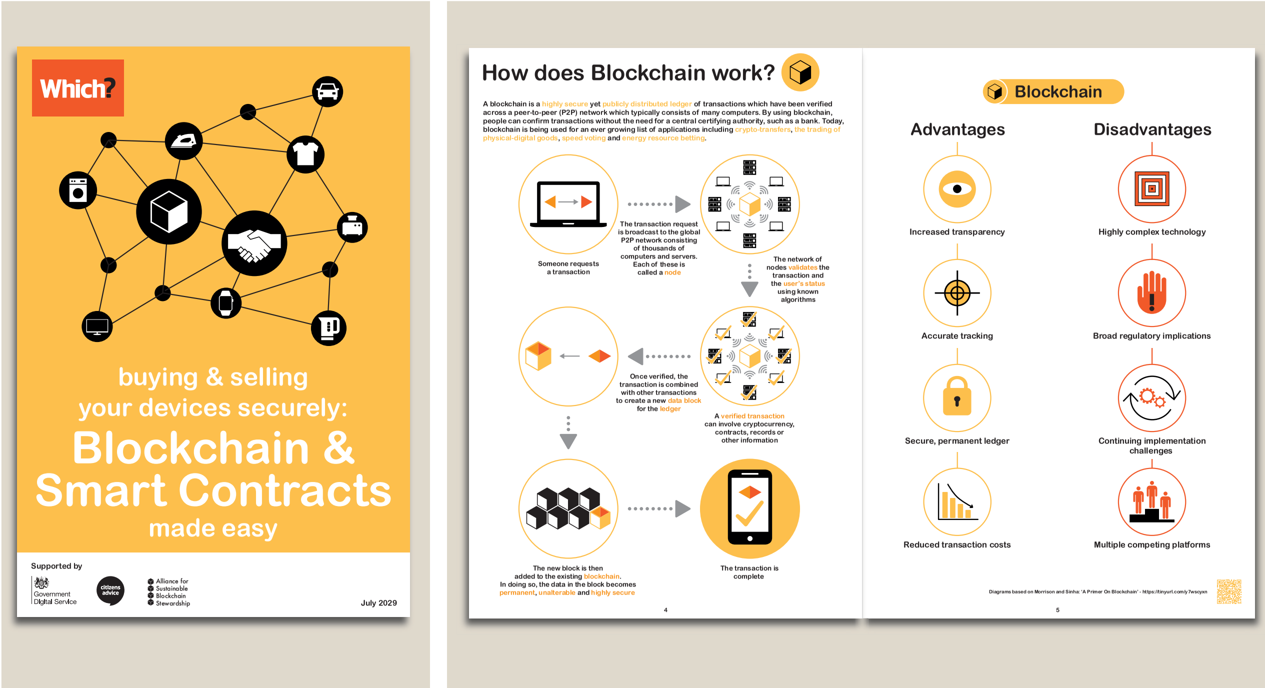


Figure 24. A near future Which? help guide for buying and selling physical-digital devices securely using blockchain and smart contract technologies.

Figure 25. Built on blockchain technology, *Lazarus* enables people to securely gift away data rich physical-digital objects, search for recycled items and access product metahistories which include important provenance data..

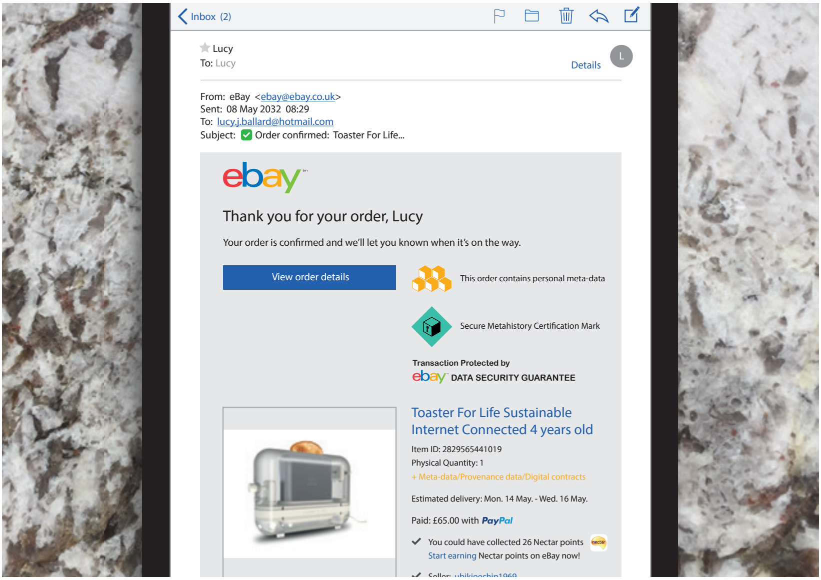


Figure 26. eBay has included the *Secure Meta-History Certification Mark* in this transaction as it involves blockchain processes and the transfer of the toaster's seller's personal metahistory data.

processes which ensures the safe transfer of the toaster's seller's personal metahistory data.

While the impacts of blockchain technologies themselves are not of specific detriment to the environment, some of the mining activities that they facilitate – the cryptocurrency Bitcoin being a prominent example – are known to consume copious amounts of energy, increase carbon emissions, and generate large amounts of heat.[27] This then presents the question – *does the negative impacts of mining practices, and by association metahistory, nullify any sustainable benefits that might result from adopting spimes as an alternative to the IoT?* Our Design Fiction prototype does not aim to answer this complex question, but it does seek to provoke a debate around such issues. We have purposely included the artefacts in Figures 27 - 29 to connote to audiences that the fictional world we have built is not

[27] Karl. J. O'Dwyer and David Malone, 2014, *Bitcoin Mining and its Energy Footprint*, in Proceedings of 25th ISSC/CIICT Conference, 26–27 June 2014, Limerick.

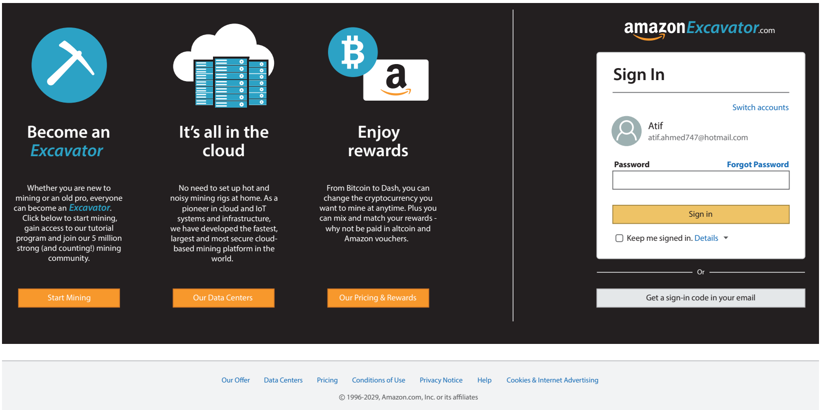


Figure 27. A web interface for a metahistory data-mining platform operated by the Internet giant *Amazon*.

Figure 28. Protest badges and a photo of protestors at the *Make Metahistory HISTORY* march through London, June 2028.

a *sustainable utopia*. Like any other techno-culture, spimes would likely have advantages and disadvantages. Although the current concerns about the sustainability of blockchain are yet to be resolved, that doesn't mean that they can't be in the future.

The Future Is Metahistory serves as a means to ask whether making spime product data more open and transparent would place greater sustainable accountably upon designers and producers in relation to the resources

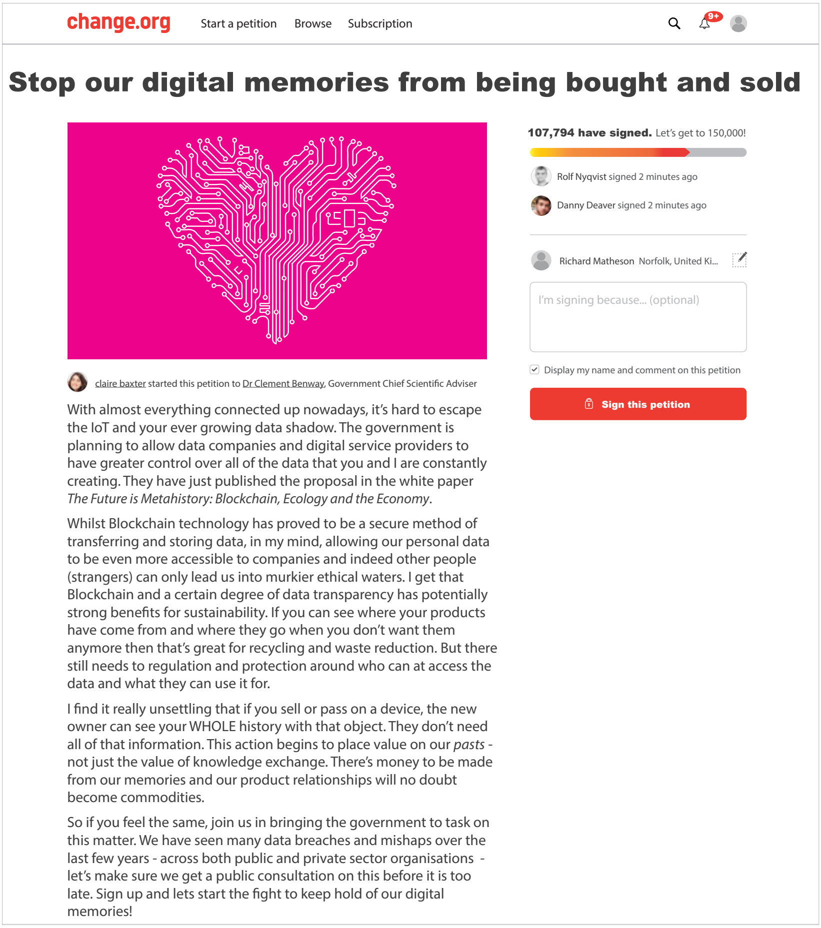


Figure 29. This *Change.org* petition highlights concerns that some people might have regards future 'open traceability' and widespread adoption of blockchain enabled personal meta-data exchange.

they deplete to manufacture connected products, as well as making these issues more explicit to the users of such devices. With present day concerns surrounding how internet service providers harvest and monitise peoples' personal data, the prototype also aims to open up debate regarding the regulation of access to connected product data and for what purposes said data may be used.

Spimes: A Lens for Designing Sustainable Connected Product Futures

Using the insights gained from each prototype, we developed a set of three, theoretical sub-lenses through which spimes can be considered:

- Based on the *Toaster for Life*, we identified *Lens 1: Business models and Behaviours* - current IoT business models would have to radically change in order to facilitate a device like the *Toaster for Life*. Manufacturers would need to stop utilising *planned obsolescence* strategies, put long-term product after-care services in place and revise product warranties to allow for user customisation and repair. With regards to *user behaviour*, the *Toaster for Life* would actively involve its owner in its lifecycle. This would make users more accountable in regards to how they use their connected devices and how they go about responsibly disposing of them when they are no longer needed.
- From *HealthBand*, we identified *Lens 2: Policy and Innovation* – for connected products such as *HealthBand* to be developed, policy and

legislation would need to adapt to accommodate and nurture decentralised and democratised IoT design culture, allowing for localised production while maintaining adequate product safety and quality standards. In addition, with open source technologies and domestic fabrication tools becoming ever-more affordable and accessible, more should be done to encourage people to get involved in these types of activities, not only for sustainable reasons but also because of their creative and altruistic benefits.

- Resulting from *The Future Is Metahistory*, we identified *Lens 3: Ethics and Ownership* – to optimise spime metahistories for sustainable change, technology platforms and services would have to make all their data processes and digital infrastructures much more transparent to users. The way in which peoples' personal data is handled throughout the IoT today is incredibly complex, difficult to trace, almost invisible to users, and probably unlawful in certain aspects. In light of recent breaches like the Facebook/Cambridge Analytica scandal, data transparency is something tech firms need to consider with a matter of urgency. Further to this, as it's difficult to keep track of what happens to it, we need to take back ownership of our IoT data. We should do more to protect it by being more careful with regards to how we interact online and what information we share.

Figure 30 illustrates the interdependency of these sub-lenses and design criteria and how they all come together to form an overarching *multidimensional lens for spimes*.[28]

[28] The formation of the multidimensional lens is outlined further in Michael Stead, Paul Coulton and Joseph Lindley, 2019, *Spimes Not Things: Creating A Design Manifesto for A Sustainable Internet of Things*, in the Proceedings of the European Academy of Design Conference 2019.

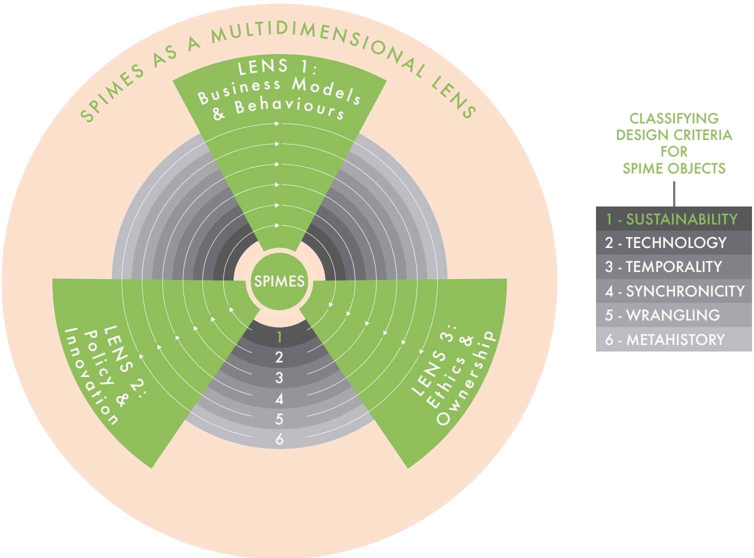


Figure 30. Following our design fiction prototypes, we identified a set of three, broader theoretical lenses. The *key design criteria* run through all three lenses, which, when viewed together, form the macro *Spimes As A Multidimensional Lens*.

Conclusion

The Design Fiction prototypes presented not only highlight and critique the unsustainable design culture that pervades the IoT, they also envision potential, plausible alternative design approaches for current connected products and practices. When it comes to designing sustainable devices, it is often easy to fall into a vicious circle of wanting to design something but then not wanting to design anything at all because you are acutely aware of the environmental damage that your product will inflict if placed into production. This is why we think spimes, and using Design Fiction to explore them, are a compelling route forward for sustainable connected product design. As we have shown, sustainability should be fundamental to any connected product design process. Meanwhile, Design Fiction methods allow us to prototype spime-like devices and consider the potential sustainable impacts and value of these designs without having to put them into production to only then discover their environmental implications.

Figure 31 depicts how, throughout human history, the shift to each new pervading techno-culture has led to an exponential increase in the number of physical devices being produced. By default, each shift has also resulted in ever-greater amounts of unrecyclable physical product waste being created. On the graph, we have included the recent emergence of the IoT within the gizmos techno-culture, and show how, unless sufficiently challenged, IoT gizmos will continue unabated on their unsustainable upwards trajectory (blue). A second trajectory (green) denotes a spime-based paradigm emerging from today's IoT gizmo landscape (yellow). We think that a transition to a spime culture in the near future could potentially reduce the numbers of disposable connected devices being created and subsequently redirect connected product design cultures onto a more environmentally sustainable path.

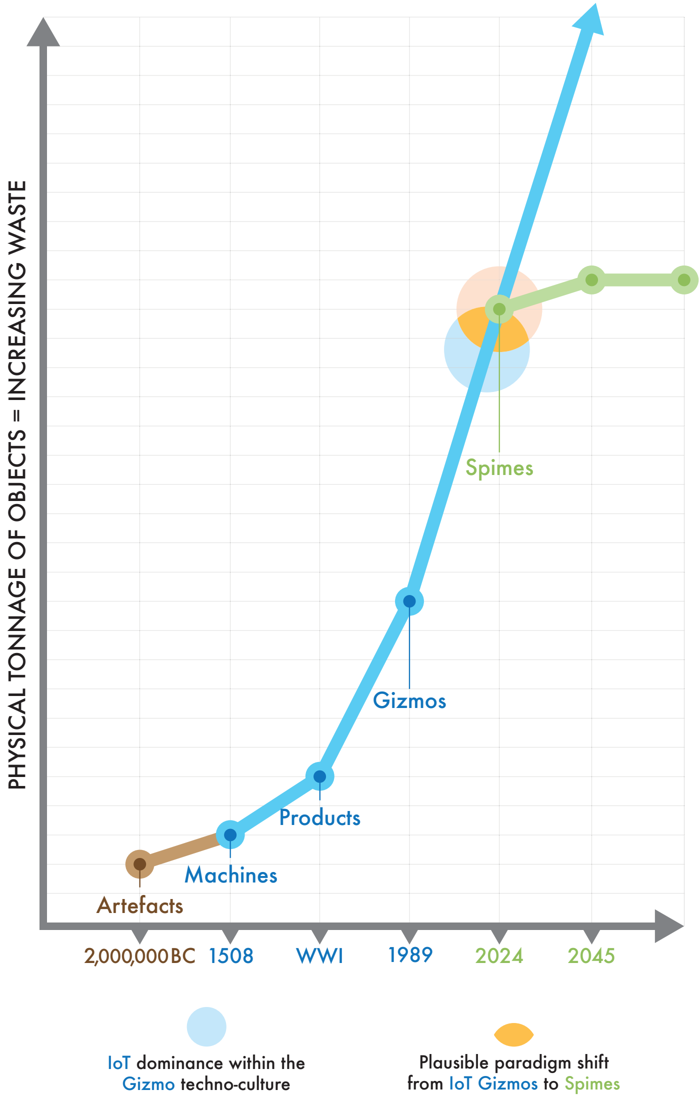


Figure 31. Shifts in techno-culture has led to an exponential rise in numbers of physical objects being produced and, by default, product waste generated. We argue that unless challenged, the IoT will continue this trend unabated. We posit that through the application of *spimes as multidimensional lens*, designers can start to reframe their design practices around a more sustainable IoT product paradigm.

References

Sterling, B. (2005) *Shaping Things*, Cambridge: MIT Press.

Rittel, H W. J., & Webber, M. M. (1973) *Dilemmas in a General Theory of Planning,* Policy Sciences, 4: 155–169. DOI:10.1007/bf01405730

Fuller, R. B. (1968) *Operating Manual for Spaceship Earth*, https://web.archive.org/web/20100717141812/http://bfi.org/about-bucky/resources/books/operating-manual-spaceship-earth

Ashton, K. (1999) *"That 'Internet of Things' Thing"* The RFID Journal, 2009. http://rfidjournal.com/articles/view?4986

Greenfield, A. (2006) *Everyware: The Dawning Age of Ubiquitous Computing*, Berkeley: New Riders.

Packard, V. (1967) *The Waste Makers*, Buckinghamshire: Pelican.

Fry, T. (2009) *Design Futuring: Sustainability, Ethics & New Practice*, Oxford: Berg.

Slade, G. (2007) *Made To Break: Technology & Obsolescence In America*, Harvard University Press.

Papanek, V. (1971) *Design For The Real World*, St Albarns: Paladin.

Diener, A. (2010) *Afterlife: An Essential Guide To Design For Disassembly*, https://www.core77.com/posts/15799/afterlife-an-essential-guide-to-design-for-disassembly-by-alex-diener-15799

Shedroff, N. (2009) *Design Is the Problem: The Future of Design Must Be Sustainable*, New York: Rosenfeld.

Webster, K. (2015) *The Circular Economy: A Wealth Of Flows*, Ellen MacArthur Foundation Publishing.

Braungart, M., & McDonough, W. (2008) *Cradle To Cradle: Remaking The Way We Make Things*, London: Vintage.

Strengers, Y. (2013) *Smart Energy Technologies In Everyday Life: Smart Utopia?*, Basingstoke: Palgrave Macmillan.

GOV.UK. (2013) *Smart Meters: A Guide*, https://www.gov.uk/guidance/smart-meters-how-they-work

www.Smartbe.co. (2019)

www.Quirky.com. (2019)

www.Skiin.com. (2019)

Sadowski, J. (2016) *Companies are making money from our personal data – but at what cost?* https://www.theguardian.com/technology/2016/aug/31/personal-data-corporate-use-google-amazon

Stead, M., Coulton, P., & Lindley, J. (2019) *Spimes Not Things: Creating A Design Manifesto for A Sustainable Internet of Things*, in the Proceedings of the European Academy of Design 2019.

Coulton, P., Lindley, J., & Cooper, R. (2018) *The Little Book of Design Fiction for the Internet of Things*. PETRAS Cybersecurity of the Internet of Things Hub. ImaginationLancaster.

Stead, M. (2017) *Spimes and Speculative Design: Sustainable Product Futures Today*, Strategic Design Research Journal, https://doi.org/10.4013/sdrj.2017.101.02

Stead, M. (2016) *A Toaster for Life: Using Design Fiction to facilitate discussion on the creation of a Sustainable Internet Of Things*, in the Proceedings of Design Research Society Conference 2016. https://doi.org/10.21606/drs.2016.455

Kohtala, C., & Hyysalo, S. (2015) *Anticipated Environmental Sustainability of Personal Fabrication*, Journal of Cleaner Production, 99, 333–344.

von Hippel, E. (2005) *Democratizing Innovation*, Cambridge: MIT.

Stead, M., Coulton, P., & Lindley, J. (2018) *Do-It-Yourself Medical Devices: Exploring Their Potential Futures Through Design Fiction*, in the Proceedings of Design Research Society Conference 2018. https://doi.org/10.21606/dma.2018.475

O'Dwyer, K. J., & Malone, D. (2014) *Bitcoin Mining and its Energy Footprint*, in Proceedings of 25th ISSC/CIICT Conference, 26–27 June 2014, Limerick.

PETRAS

EPSRC