Designing For The End of Life of IoT Objects

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Abstract
The Internet of Things (IoT) and ubiquitous computing are leading to an increase in objects with a short lifespan - either through breakage, “bricking” by the manufacturer, or discontinued use by the owner. This leads to a surplus of material and e-waste that cannot or is not readily recycled, upcycled or otherwise reused, aggravating material scarcity. In part, this is due to custom-built hardware, and use of unrecyclable materials. However, it is also due to the limited value people place on these objects (e.g., sentimental and environmental). This one-day workshop will explore how the configuration of values designed into IoT objects influences the end-user practices of disposal, recycling and upcycling. Through this lens, we will collectively consider potential design strategies that can be instilled during the process of design, to support the continuity of the material life of IoT objects after their “death”.

Author Keywords
Internet of Things; sustainable HCI; design values; spimes; cradle to cradle design.

CCS Concepts
•Human-centered computing → Human computer interaction (HCI); •Social and professional topics → Sustainability; Please use the 2012 Classifiers and see this link to embed them in the Tex.

Themes and Goals
What types of value, beyond the functional and performative, encourage sustainable end-of-life practices for IoT objects? This workshop will answer this question, by addressing the following themes:

1. What values compel people to keep, reuse or reimagine IoT objects after they are no longer functional?

2. What strategies can we use to design these values into IoT objects, to encourage end-of-life upcycling, appropriation and reuse?

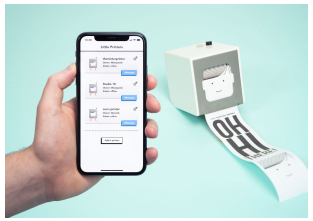

Figure 1: An image of the bricked Little Printer alongside the new software developed by Nord Projects to revive it [8]

Background and motivation

IoT objects, ranging from mass-produced products like smart watches and home assistants, to small-scale designerly objects like the Little Printer [8] (Figure 1) and Goodnight Lamp [5], are part of an ever-expanding family of connected devices, which can be seen to have a limited lifespan. IoT objects can suffer from breakage, loss of functional value (the ability of the object to fulfil a functional role in its owner's life) and loss of performative value (the ability of the object to signify its owner's status or belongingness to a social group). For example, the performative value of a branded smartwatch may be depreciated when a new model is released, and its functional value may likewise be reduced when newer models are infused with new, compelling features. The lifespans of IoT objects are also mediated by their duality as *data objects* and *material objects*; even while the material body of an IoT object remains functional, a company may shut down its servers at any time, thereby depriving the object of its functionality and rendering it a "brick".

This raises the question: what happens when an IoT object has come to the end of its life? With typical objects, the owner can choose to keep hold of the item indefinitely, repurpose it, sell it for parts, recycle it or throw it to landfill. However the use of glues, hidden seals, force fits, and non-recyclable plastics in IoT objects make them difficult to recycle. Custom-built hardware together with closed-source software may also make them difficult to hack, reuse or reimagine [8]. The issue of IoT object 'death' has both ethical and environmental dimensions. Metals and minerals used to produce these devices, such as silicon, copper, gold, and lithium, are often mined using unethical practices in developing countries [6]. These materials eventually turn into e-waste that poses serious environmental and public health risks [13]. The limited lifespan of IoT objects, together with the environmental and ethical implications of their lifecycles, demonstrate the importance of considering their end of life, from the beginning design stages.

Promoting Life After Death With Design Values

This workshop will address whether and how constellations of values designed into an IoT object can mediate its lifecycle - by compelling people to keep, reuse, recycle the object, or reimagine its use after its functional or performative 'death'. For example, when an object retains its monetary value but not functional value, the owner may choose to sell it for parts, while if it retains sentimental but not functional value, the owner may choose to keep it hidden in a cupboard or displayed on a shelf indefinitely. What constellations of values would compel owners to reimagine an IoT object's use and function after its death, and how can these be designed for? We hypothesise that end-of-life upcycling, appropriation and reuse can be mediated by designing for emotional, sentimental, environmental, ethical and moral values - among others.

Work from both academia and industry has begun to suggest how imbuing a variety of values into IoT objects can support their owners in reflecting upon their materiality, as well as supporting their 'life after death'. One focus has been on making the environmental value of IoT objects more explicit and tangible. With his concept of *spimes*, Sterling posited a future techno-culture where physical objects exist alongside their digital representations; in this spime-based future, Internet connectivity would enable physical objects to be tracked and traced throughout their entire lifecycle, from their initial design and production, to the recycling and reuse of their material components at the end of their life [12]. The spimes concept thus reframes IoT connectivity as a tool for *environmental change*. By adopting the spimes approach, Stead et al. contend that the lifecycle

Figure 2: The Sprout pencil, which finds a new life as a plant in a re-purposed tennis ball [10]

Figure 3: A framed image and a mug depicting Jibo alongside its owner [2]

of future IoT objects could be designed to be transparent and tangible - leading to greater accountability amongst users, helping them make more sustainable decisions about the connected products they purchase, how they use them, and, ultimately, how they go about disposing of them [11].

In turn, another method of making environmental value explicit is the “cradle to cradle” design philosophy - which ensures objects are, from their inception, designed in such a way that their “waste” is reenvisioned as “food” for new material instantiations [1]. A simple example is the Sprout pencil [10] (Figure 2), embedded with seeds to be planted instead of thrown away, once the functional value of the pencil is depleted. This workshop will address how this design philosophy might be envisioned to apply to IoT objects.

Speed and Maxwell, in turn, have sought to counter the common narrative around producers absolving themselves of a product’s subsequent lifecycle, leaving the consumer to deal with its waste at the end of the product’s value chain. Instead they look toward a model of service innovation in which distributed stakeholders in an ecosystem can co-create value according to their own needs [9]. Such ecosystems require manufacturers to relinquish their control of the value proposition from cradle to grave, and instead allow products to be repurposed according to the interests and designs of stakeholders in the wider constellation.

Beyond work on environmental value, case studies of “bricking” of anthropomorphic IoT objects by companies showcase how end-of-life practices for objects can change, when they are designed to have sentimental or emotional value. Embedding sentiment and emotion into objects is a long-standing design principle for supporting longer retention by their owners [3, 7]. A recent ‘viral’ example of the power of emotional value in mediating an IoT object’s end of life was the social robot, Jibo (Figure 3), which announced its own ‘death’ when the company behind it shut down its servers, by saying, "*maybe someday, when robots are way more advanced than today, and everyone has them in their homes, you can tell yours that I said hello.*” The owners’ emotional attachment to Jibo led many to deliberate what to do with Jibo’s material body, with some keeping it displayed on a shelf as a way of remembering its ‘life’, and others even debating whether to bury it as one would a pet [2, 4].

Another example is the Little Printer - an anthropomorphic IoT thermal printer [8]. After its founders “bricked” the Little Printer, many owners kept it on their shelves, despite its loss of functional value. Observing the owners’ attachment to their Little Printers, an independent design studio called Nord Projects resurrected them by building a new app for the Little Printer hardware, giving it a new lease on life [8]. This shows how owner attachment can also compel industry to use open source software and standards, to allow people to hack and reimagine their devices after the end of their production and support [8].

Examples like these demonstrate how the design of value into an IoT object, beyond functional and performative, can augment its ‘life after death’, or at the very least, promote reflection by its owners about its end of life – leading them to engage with its materiality and the implications of the waste it leaves after it ceases to function. Thus, there is an opportunity to consider how to design IoT objects from the beginning, to support how they are reimagined/repurposed at their end, by embedding them with values, such as emotional and environmental. Through this workshop we will: (1) explore the values that compel people to keep, reuse or reimagine IoT objects; (2) ideate design strategies for instilling a diversity of values into IoT objects to encourage end-of-life upcycling, appropriation and reuse; and (3) strengthen and expand the community of designers, practi-

tioners, and researchers who collaboratively and creatively explore solutions around sustainability and IoT.

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