Addressing the Obsolescence of End-User Devices: Approaches from the Field of Sustainable HCI

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Abstract. The progress of technological development and the resulting rapid replacement of end-user devices has brought increasing issues of electronics waste upon our society. Interaction designers and researchers within the field of human-computer interaction have begun to tackle issues of environmental sustainability in recent years, including the problem of obsolescence. By considering the experiential aspects of obsolescence and the ways in which interaction design could have an impact on experience, the field presents promising approaches with potential to contribute to and complement current materials-focused solutions. In this chapter, we report on a survey of sustainable human-computer interaction research that investigates or addresses issues of obsolescence, presenting challenges as well as opportunities for interaction designers to contribute to solving these issues.

Keywords: Human-Computer Interaction, Sustainable HCI, Sustainable Interaction Design, Consumer Electronics, Obsolescence.

1 Introduction

The term obsolescence is used to describe the conditions of objects to become outdated and lose their usefulness—they become obsolete. While the term is often wrongly used as synonym for "planned obsolescence," a concept introduced by marketers in the beginning of the 20$^{\text{th}}$ century [1], the traditional meaning of the word does not imply any planned action or bad intent. For the domain of consumer electronics, obsolescence can simply be used to describe the logical conclusion of the rapid development of technology. Therefore, we consider obsolescence in its broader definition which includes, both planned obsolescence as well as obsolescence resulting from a more natural loss of functionality. Although the progress of technology is inevitable, as can be observed through the applicability of Moore's Law [2] to decades of development, this does not imply helplessness towards obsolescence: Research in the domain of interactive technology has influenced and will continue to influence the future of technological development, and subsequently have an impact on obsolescence as well.

The field of human-computer interaction (HCI) has become increasingly interested in leveraging the potential of HCI research to make an impact in environmental sustainability [3,4]. In particular, the proposal of a rethinking of interaction design towards a new paradigm of *sustainable interaction design* (SID) [5] marked the starting point for a plethora of research in the following years. Blevis proposes that "*sustainability can and should be a central focus of interaction design*" [5], and argued that—among other efforts—obsolescence can be addressed if "*things are designed and constructed with sufficient quality and modularity*". In subsequent years, sustainable HCI (SHCI) evolved from an emerging topic to an established, well-published sub-community within the field of HCI, appealing to a variety of environmental sustainability issues, among them the issue of technology obsolescence.

Various researchers working in sustainable HCI have argued to counter obsolescence by tackling the issue by its core definition—making products less prone to obsolescence. For example, this can be achieved by making sure the product itself comprises durable materials [5], lasting for at least ten years minimum [6]. Similarly, another approach that considers the hardware of devices is to enable upgradability [5–9]; a common example is that of modular phones as explored several years ago (e.g., WILLCOM WP004[1]) and again more recently (e.g., Project ARA[2]). This notion of upgradability does not only apply to hardware, but has also been proposed for software [5]. By allowing software upgrades or the installation of new applications, otherwise obsolete devices can even be repurposed for other uses, e.g., by turning PDAs into ebook readers or GPS trackers [10].

All these approaches target the device's hardware or software directly, and as such can be considered as conceptually straightforward, but difficult-to-realize solutions to obsolescence. HCI research, however, considers not only the design of technology itself, but also the implications of the design on the user experience. In the following, we will present an overview of SHCI literature that investigates or addresses issues of obsolescence by focusing on the implications for user experience and how influencing the user experience might change the pathway to obsolescence. We provide a brief overview of important SHCI research streams and elaborate on our literature selection process. The main part of this work presents a variety of design considerations that have emerged from work in this field, highlighting the diversity and potential of interaction design to contribute to sustainability and reduce or slow technology obsolescence. By categorizing the obsolescence-related work in the field of SHCI we hope to enable researchers and practitioners from other fields to make use of insights from SHCI research and build upon this work to discover new research avenues that tackle the problem of obsolescence.

[1] http://www.engadget.com/2007/04/13/willcom-shows-off-customizable-wp004-handset/

[2] http://motorolaara.com/

2 Sustainable HCI—Background

The field of SHCI is a rather young field, but has seen a tremendous amount of activity in recent years. The SIGCHI conference[3] 2007 is widely regarded as the event that established SHCI as a major area with two highly influential landmark works [4, 5]. In the years since, SHCI has grown into a large research field with several different directions, uncovering a variety of potential pathways via which HCI can contribute to issues of sustainability. In a survey analyzing the existing work in the field, DiSalvo et al. [3] highlighted the potential of HCI research in this area. There are two major streams to distinguish or classify work in SHCI: *sustainability through design* and *sustainability in design* [4].

Sustainability through design denotes the study and development of technology that can be leveraged to pursue sustainable goals. Various approaches have been presented that attempt to influence the decision-making process, induce behavior change, persuade people to engage in sustainable actions, or simply raise awareness through feedback technology, often referred to as *eco-feedback* (for surveys of the research in this field, see [11–13]).

Sustainability in design strives to reduce the material effect of hardware or software itself, making a direct impact for sustainability in the design itself, regardless of its application and use. It is strongly connected with the primary intention of Blevis's seminal paper that fueled the field in 2007, introducing the term *sustainable interaction design* [5]. He argues that it is not sufficient to just apply sustainability to existing solutions or add sustainability principles somewhere in the process of interaction design, but that sustainability has to become the central focus of interaction design to be successful in making an impact for sustainability. The paper concludes with the hope that sustainable interaction design can in fact overcome issues of obsolescence: "*If things are designed and constructed with sufficient quality and modularity, people may be inclined to look after them and selectively update them, creating the effect of achieving longevity of use.*"

Although sustainability in design deals directly with problems of obsolescence, sustainability through design also provides important insights by looking at the issues and proposing solutions from a different perspective. The definition of interaction design supports the diversity of potential opportunities of HCI research: "designing interactive products to support the way people communicate and interact in their everyday and working lives" [14]. Since products can refer to both hardware and software, sustainable interaction design does not only apply to the design of physical objects, but also digital artifacts that support people's interaction and communication in everyday life to become more sustainable.

In this chapter, we analyze the current state of SHCI research that has dealt with and appealed to the problem of obsolescence for technology. Our approach was to consider all publications related to both HCI and sustainability that address obsolescence directly or indirectly. In the literature review process, our focus was to gather insights through two primary approaches: first, identifying

[3] http://www.sigchi.org/conferences

common themes in the solutions proposed for interaction design; second, highlighting challenges mentioned in SHCI research emerging from previous work. In the following sections, we present the results of our analysis of the field, categorized by three themes that emerged as high-level categories in our analysis: values in design, re-use, and longevity. These three categories represent three equally important dimensions along which obsolescence-related SHCI research can be oriented. For each of these themes, we highlight a number of design considerations that have emerged from SHCI research and discuss them in light of their significance to issues of obsolescence and potential challenges in application.

3 Design Considerations in Sustainable HCI Research Addressing Obsolescence

3.1 Values in Design

Many approaches to address obsolescence can be attributed to conveying value in design. The common idea is that an object whose design expresses or comprises a certain quality (e.g., in terms of aesthetics, interaction, or usefulness) is less likely to be replaced, thus creating an innate resistance to obsolescence. In his definition of sustainable interaction design, Blevis incorporates values as one important aspect in design [5], highlighting different aspects of design values as presented in previous literature and design practice. For example, design can be about "features and functions of objects", "affective aspects of objects", "interactions between people and environments", or "choices that lead to sustainable futures". Similarly, SHCI research presents different concepts of values in design.

Pleasure Engineering. Even before sustainability became a major subject within the domain of HCI, Woolley [8] related the rapid replacement of products with a shift from pleasure (upon purchase) to dissatisfaction (long-term use). He therefore calls out for *pleasure engineering*, creating designs that enable long-term pleasure, and ultimately defer or even avoid the dissatisfaction over time. Four strategies are proposed to achieve such a long-term satisfaction: future-proof design in functionality and appearance; price reduction incentives; no incremental changes but fewer and larger steps in technological advancement (cf. Moore's Law—contracting steps); and as a last resort, governmental regulations. Some of these strategies, e.g., regulations or a product's price, cannot be addressed by HCI approaches directly. The design of services and technology that support everyday work practices of various stakeholders outside of HCI offers opportunities for interaction designers to indirectly achieve an impact on practices that lead to more sustainable actions.

Achieving Heirloom Status. The research of Hanks et al. [15] considers the attitudes of young adults towards sustainability, specifically regarding ownership of objects. Through a survey of college students, they discovered that students did not believe that they would pass electronic devices down to their children. They argue that interaction design should strive to *achieve heirloom status*, turning electronics into objects that are worthwhile not only to keep, but even to inherit. While heirloom status is a design value mentioned by many researchers in SHCI [5, 16, 17], it is difficult to design for and difficult to study as it only develops over time. Studies of objects that people hold on to for a long time can provide hints as to how design technology to achieve a similar impact [18,19]. In the specific case of electronics, heirloom status might not only apply to physical material, but also the digital dimension of products (see *value of the content, not the device* as reason to keep objects [20]). This interplay of physical and digital properties might create new opportunities for HCI to support the process of establishing heirloom status, if not only the physical product itself becomes a heirloom, but the software, applications, or content on it is perceived so valuable that people want to pass it on.

Ensoulment. By studying people's attachment to objects they would not discard, Odom et al. [18] identified *histories* as one reason for holding on to products—the object helps the owner to preserve a memory. In a study focused around electronic waste, Zhang and Wakkary [21] made a similar observation by highlighting *emotional connections* as one reason why owners do not dispose of their electronics. Those are two examples of *ensoulment* in practice; a term introduced to HCI by Nelson and Stolterman [22] and later on applied to SHCI [23]. It refers to the notion that a product, due to its design, is perceived by the owner as having a soul, establishing an emotional bond that prevents disposal and encourages longer ownership. Related terms are *emotional design* [24] and *attachment* [18–20]. Furthermore, Odom and Pierce [18] suggest to foster such a connection through *narratives* and *character*, and provide the example of an MP3 player resembling a musical passport which, each time the owner enters a new country, allows to virtually "stamp" it, creating a memory and accumulating a travel history over time.

Slow Design. Based on the *slow movement* which proposes a cultural shift towards a new lifestyle with slower pace and increased awareness of one's environment, *slow design* is an approach that targets a people's everyday life beyond just the interaction with one product. Slow design aims to slow the metabolism, resource consumption, and flows of people's life, engendering a positive behavior change. It can be seen as not only addressing obsolescence through the design of products itself, but calling for a change in people's lifestyle in general. Hallnäs and Redström [25] argue that products conveying slow design cause their owners to be more reflective of their interactions and practices, and Strauss and Fuad-Luke [26] pointed out that slow design principles have a positive impact on the design process itself as they open up new perspectives about the potential of designs and their message. A recent slow design case study supported these insights with similar responses from both designers and evaluators [27]. The core idea is that products conveying slow design contribute to a lifestyle resembling more reflection and awareness, ultimately increasing individual wellbeing, both on an individual as well as on a societal and cultural level.

New Luxury. Blevis et al. [9] discuss *new luxury* as an additional opportunity for sustainable interaction design to promote a shift to a more sustainable design of consumer electronics. The concept of new luxury as a contrast to more expensive and exclusive definition of traditional luxury is defined as "*products and services that possess higher levels of quality, taste, and aspiration than other goods in the category but are not so expensive as to be out of reach*" [28]. Blevis argues that this level of quality introduced by new luxury can contribute to SHCI efforts, for example, by promoting "services over new physical materials", "upgrades of existing products", or "concern for secondary markets". Several authors have noted that luxury and material success are obstacles in tackling obsolescence [9, 15, 29] since some consumers—commonly referred to as early adopters—always like to have the most novel technology [15]. New luxury might be leveraged to turn this traditional notion of material success and luxury against itself to promote more a more sustainable behavior, for example, by shifting the societal paradigms such that owning a device for a longer amount of time becomes more desirable than buying a new one.

3.2 Re-Use

Another approach to extending the lifetime of electronics—partially or for the whole device—is to design for reuse. These concepts all have in common that some aspect of the relationship between the owner and its device changes, such as changing the owner of the device (transferring), changing the device itself (repairing or recycling), or changing the way people interact with it (repurposing). While the conceptual design of the device itself can encourage and support reuse, observations and studies show that it is often difficult to anticipate what will lead to successful practices. However, interaction designers can also offer support for reusing existing devices, such as by creating tools to share ideas and examples or encourage and support practices of reuse.

Transferability. The lifetime and usage of consumer electronics can be extended if the design of such devices supports and encourages *transferal of ownership*. Hanks et al. [15] propose a rethinking of design such that electronics keep their value of functionality, similar to automobiles. Blevis's rubric [5] also names transferability as an important aspect of sustainable interaction design, calling for "*reuse as is*". In a study comparing mobile phone transferability in three different countries, Huang et al. [30] discovered that there are different attitudes towards transferal of ownership. While in Japan privacy concerns were an issue, leading people to manually destroy and discard their phones rather than selling them, several Northern American participants were unable to transfer their phone due to them being locked to one service or contract. This highlights that depending on context there are different barriers to transferability and different ways of addressing the issue; for example, while the issue of privacy is a matter of decoupling digital contents from a device and making this trustworthy and transparent to people, contract or service issues are an external issue that can only be addressed indirectly by interaction designers. In the same study [30], German participants mentioned that it was economically advantageous and thus often preferred to pass on phones to acquaintances or sell them upon acquisition of a new phone, showcasing an example of encouraging transferal of ownership. Interaction designers can leverage this knowledge by designing services to support these ownership transfers, creating a desire for more opportunities for transferability and thus indirectly making an impact on existing policies and roadblocks to transferability such as contract or service locks. Additionnally, designers to support transferability explicitly through the design of devices themselves and their software.

Repair. One of the innate characteristics of obsolescence is that devices break and stop functioning—be it through purposeful design or through unintended malfunctioning. Maestri and Wakkary [31] studied how laypeople repair broken objects, including but not limited to electronics. They argue that interaction design should support the manufacturing of products that allow for them to be repaired without specialized knowledge; a concept they call *everyday design*; the implication is that everyone is a designer or, in the context of their study, a repairer. In an extension to the first study Wakkary et al. [32] provide additional examples and conclude that the material of a product should allow for repair by laypeople based on people's expected competence in repair, and the product's design should allow for repair without the requirement of special tools.

Re-use of Materials. Through an online survey about electronic waste re-use examples, Kim and Paulos [33] developed an extensive design reuse vocabulary for material properties, shape properties, and operation properties of electronic waste. Their framework provides designers with actionable guidelines for the design of electronics that allow for re-use through partial or complete disassembly. But it is not only the materials themselves that are important to consider for re-use of technology; in a study of electronic waste recycling practices, Zhang and Wakkary [21] identify that the disposal of electronics and the information about available electronic waste for re-use needs to be organized. They suggest local recycling information networks to support electronic waste re-use practices. In a framework for sustainability assessment by Dillahunt et al. [6], several criteria call out for a better re-use support as well, such as *modular devices that can be taken apart easily*, materials that can be *replaced*, *reused*, or *recycled*. The latter two criteria also appear in Blevis's rubric [5] as *recycling* and *remanufacturing for reuse*.

Augmentation. A rather difficult design proposal but one that, as studies show, can be very successful to extend the lifetime of a product, is to allow for an object to be augmented beyond its intended use. Odom et al. [18] call this augmentation; further examples for augmentation can be found in the follow-up study by Gegenbauer and Huang [19], e.g., “an alarm clock to which the owners had attached a light” or an embroidered chair. An impressive and exceptional example in the domain of consumer electronics is that of a combination of 30-year-old computer technology currently being used by children in Indian communities [34]; this use is only possible due to the design of the original technology itself that did not prevent or constrain such repurposing of the device. Huh et al. [10] present a similar observation for more recent devices, when PDAs acquired through eBay were used as ebook readers or a cheap alternative to GPS devices. Note that both these examples resemble aspects of transferability as well since they include change of ownership; but the key aspect that enables an extended lifetime is the repurposing and augmentation of devices beyond their intended use.

3.3 Longevity

One theme in SHCI to address obsolescence is that of achieving real durability and longevity. This differs from reusability as it aims for longer ownership without changes in the relationship, tackling obsolescence at its core. Therefore its largest barrier is planned obsolescence, which is the exact opposite of durability; instead of designing a device to break, durability argues that a device should be designed to last longer. Interaction designers can contribute to solutions for issues of obsolescence by laying the foundation of longevity through functionality and motivating longevity of use among consumers.

Longevity of Functionality. Gegenbauer and Huang propose a design principle called *sufficiency*, defined as the “extent to which an object continues to be used or kept because it is capable of serving its intended purpose” [19]. Odom et al. [18] present a similar notion by defining the design criteria of *perceived durability*, encouraging the design of long-lasting objects due to their functionality, simply inherent longevity, or both. Designing for longevity is particularly challenging as it require thinking about not only whether design is usable and useful now, but also predicting whether it will be in the future. However, the important premise of this approach is to make sure that the core functionality of the object will work in the long-term, as this is a requirement to achieve longevity in the first place.

Intrinsic Motivation for Longevity. Another aspect of longevity is that of raising awareness of the benefits of holding on to one object rather than engaging in a rapid replacement process. The concept of slow design as highlighted by an exemplary design concept study [27] creates an intrinsic motivation for people to continue using a device, as it causes people to reflect on their interaction with technology [26] and ultimately can contribute to a change in lifestyle with regard to their attitude towards technology. Similarly, Hanks et al. [15] argue that some people prefer longevity of use for devices, fully aware of and making reference to the environmental concerns connected with rapid replacement. The combination of awareness of longevity and incentives (often intangible, almost metaphysical) can lead to a strong appeal of longevity.

4 Conclusion

The obsolescence of end-user devices is an issue that concerns many research fields and needs to be tackled on many different levels. The domain of HCI research, due to its focus on user-centered design, can contribute to solutions by addressing obsolescence by considering the user experience, the interaction between the device and its owner, and the influence of these factors on ownership, use, and disposal. We highlighted a variety of design considerations that open up opportunities to engage in new efforts to overcome the rapid replacement of consumer electronics. The categorization of obsolescence-related SHCI research allows us to identify potential solutions to the problem of obsolescence that have been repeatedly found to hold promise. Furthermore, it serves as a design space that highlights under-explored areas that offer new opportunities for research.

Although some of the approaches described in this chapter offer illustrative examples of their application to product design, many of them have yet to be applied in real-world practice. Therefore, future research needs to investigate how these concepts can be applied to the design of end-user devices in practice. We believe that in order to be successful, a concerted effort is necessary that makes use of design knowledge accumulated in SHCI in cooperation with researchers from other domains and stakeholders in practice.

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