Facilitation of sustainability through appropriation-enabling design

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Abstract
We propose that sustainable interaction design can benefit from the notion of appropriation-enabling design in the sense that designing for appropriation can promote renewal and reuse of software and hardware artifacts. To this end, we establish the relation between sustainable interaction design and appropriation, identify three appropriation-enabling design challenges, suggest tentative solutions to them and assess an existing system to illustrate effects of certain appropriation-enabling design decisions on overall system sustainability. We propose that the perspective propagated by us can further HCI paradigms that allow for appropriative interaction, thus helping to sustain computing resources by promoting the prolonged use of software artifacts. This approach is based on the assumption that prolonged use of software solutions will ultimately lead to the longevity of the hardware artifacts on which they operate.

Author Keywords
Sustainability; sustainable interaction design; interaction design principles; modular design; appropriation; appropriation support.

ACM Classification Keywords
H.5.m. Information interfaces and presentation: User-cantered design.

General Terms

Human Factors; Design.

Introduction

Here we propose the argument that the "sustainability through HCI" discourse can benefit from a design paradigm that places the opportunities for appropriation in the center of interaction design decisions. Though some HCI authors have argued that interaction design is limited in scope to address sustainability per se and that broader (political, economic, etc.) tactics are needed to address the issue [5], we have taken a different, micro-HCI stand (as defined by Shneiderman [22]) which propagates a "sustainability in design" [17] approach. Specifically, in accord with the main arguments of sustainable interaction design (SID) [1], we propose that design choices of new artefacts can have a direct effect on the disposal of existing artefacts and that interactive systems can be designed to prolong the lifespan of artefacts and their capacity for renewal and reuse. These design choices, we propose, are based on existing interaction paradigms, which can be shaped by the HCI community to foster more sustainable interaction models.

Further, our approach is to tackle the problem of rapid obsolescence of hardware artifacts by suggesting ways to prolong the life of software artifacts which run on them, thus contributing to their continued use and to the possibility of their reuse. Our assumption is that certain interaction design considerations and system design choices that aim to prolong the use of software solutions may have a positive impact on the longevity of hardware on which they function. We base our argument on the following hypothetical claim: by fostering appropriative interaction we can help the major players in the IT industry to shift from decisions on planned obsolescence of hardware to decisions on maximizing the sales of software that would be designed to meet the changing needs for functionality and the evolving need for altered experiences by end-users. In a hypothetical example, if the users have some hardware that they are not willing to use because their needs are no longer met by its functions or because they want to experience new and presumably better interaction opportunities, they would have the option of changing the interface and functions of the software to fit their new needs. Thus, by promoting and thereby shaping the appropriative behaviour of end-users, the IT industry could focus on generating more revenue from software upgrades. These upgrades would introduce highly desired newer interaction possibilities for older solutions, but would not necessitate the need for new hardware (the prevalent model today). This new model would come to replace the current situation in which companies produce new hardware with novel software to justify its procurement or introduce new versions of software, which sometimes necessitates the need for new hardware.

Related Work

In the seminal article on SID [1], Blevis suggested placing sustainability in the focus of interaction design. Thus SID propagated a value-based, normative perspective of design for "future ways of being" and proposed a set of sustainable design considerations, which included understanding of the effects of introducing new solutions on existing artifacts, considering the possibilities of renewal and reuse of existing systems, and considering quality as a construct of longevity [1]. The comprehensiveness of the ideas

presented in this initial discussion has stirred an array of discussions on SID. Among these, multiple publications, covered in DiSalvo at al.'s 2010 review on sustainability and HCI [2], have discussed interaction design choices that may promote sustainability.

Prolonged use and renewal/reuse of digital artifacts are two central themes in the SID discourse [1]. Most of the earlier studies joining the SID discourse have focused on the study of in situ use and ownership of physical (digital and non-digital) artefacts, exploring linkages between ownership attitudes and prolonged use and reuse of physical artefacts [7], [8], [10], [13], [18], [19], [24]. The notions of appropriation and re-appropriation as factors contributing to the continued use of artifacts through time have been the overarching themes in many of these studies.

Further, ideas originating from these studies stirred a number of discussions on how to promote renewal and re-use of existing computing artefacts through supporting their appropriation and re-appropriation. A CHI 2010 workshop discussed issues related to the "appropriation, re-use and maintenance for sustainability" [12]. Authors of this discussion noted that "the challenges and directions for how we might study, design, and evaluate the reuse of used and obsolete computing artifacts need further investigation. What is now needed especially, are guides to tangible action." [12]. Along with this, still largely unaddressed need, an equally important agenda for SID is to inform decisions for sustainable development of new digital products.

It is noteworthy, that the functionality of a device is considered only one of the aspects that may prolong its use. For example, prolonged use has been studied in terms of the qualities of devices that promote strength of attachment that include (among others) the symbolism that they carry for the owner and their material qualities [7], [19], [23]. However, in this text we argue that the functional qualities are an important aspect for promoting sustainability and that they, alone can have a lasting impact on sustainable use and re-use.

Successful examples and their significance

Real-life examples show how certain characteristics supporting appropriation (namely configurability and extensibility) of some systems have helped to prolong their life and sustain their continued use. A popular blogging platform and server based solution WordPress, has grown to become a state of the art content management system, used by millions of users due to the initial design decisions promoting extensibility, adaptability and tailoring. Another widespread tool, Microsoft's Excel has been widely used to develop applications and systems due to its extensible and configurable functionality that have promoted its use and repurposing beyond its initial design purpose of a spreadsheet. These types of systems introduce a "long-lasting relationship" between the users and the artifacts. Thus users tailor and re-purpose applications and come to view this process as an integral part of their work and of using systems in general. As a consequence, the main software and hardware components on which these modular applications function can remain the same over time. To the users that have experience with modular and tailorable applications, renewability and re-use are natural ways to solve problems arising from their needs. Thus, from a more general perspective, introduction and support of

appropriation-centric applications can facilitate sustainable user attitudes (since users will be convenient with tailoring applications to suit their needs) and sustainability of the software and hardware artifacts (since software and hardware would not need to be changed, but re-purposed or extended to introduce novel functionality).

Appropriation-enabling design

In an attempt to contribute towards directions to action for sustainable appropriation, we now present three appropriation-enabling design challenges and propose tentative approaches to their solution. Though the proposed solutions will not be applicable to all contexts, we believe that they can help to inform interaction design decisions for the development of software solutions with a sustainable lens.

Supporting the unexpected

Research on how users appropriate computing artifacts to suit their needs can help us incorporate design principles to support appropriation. Several authors have stressed the need for technology to be designed to support appropriations [3], [4], [6], and have studied appropriative interaction [20], [21] as a naturally occurring phenomenon. The basic challenge for appropriative design outlined by Dix [3] is the design for the unexpected. The main question is how to design interactive systems that allow for unintended uses of functionality. One of the tentative principles proposed by Dix was "plugability and configuration" [3]. Based on the successful "real-life" examples discussed above, we believe that this approach can have wider implications for the design of appropriation-enabling, sustainable artefacts. We thus propose to design for adaptation, extensibility, reconfiguration and remix of functions through modular, component based technology. We argue that appropriation design can be facilitated if the systems and services have pre-built configurability functions and extensibility mechanisms. To this end, Wulf at al. have proposed a software architecture model that enables the tailoring of component-based applications to suit the needs of the end-users [25]. We believe that the principles of component based tailorability and extensibility should be placed at the heart of appropriation-centric software artifacts and that this approach will foster interaction paradigms that allow reconfiguring or embedding new functionality into systems and services already in use, thus promoting their renewability and re-use. Thus our approach to solving the challenge of "supporting the unexpected" is to cater for component-based tailorability and extensibility as an important design decision during the development of software artifacts.

Supporting creative uses

Discussions on creativity and appropriative behavior [14], [21], [24] have contributed to our understanding that appropriations are instances of creative use of systems and that the systems need to be flexible and open to interpretation so as to enable appropriation. Thus, the second major challenge tackled here is the design for supporting the creative uses of systems by offering flexibility and openness and by allowing interpretation [3], [9]. One important factor in this process is to design for appropriation based on familiarity of the designed systems to users' real-life communication practices [9]. We extend on this notion of familiarity and argue that creative uses are easier accomplished in systems where the boundaries of flexibility and openness are familiar to the users and where they have successfully exercised "creative uses"

in the process of their appropriation practice. Thus our approach to solving the challenge of "supporting creative uses of the system through flexibility and openness" is to support seamless integration into artifacts in use in the interaction contexts.

Supporting appropriative behavior

Earlier studies suggested that knowledge of the tools in general and their specific functions in particular as well as the exchange of ideas about the actual use should be supported when designing "easily appropriable" technologies [20]. Building on similar rationale, Draxler et al. recently proposed a breakthrough prototype supporting the social context of appropriations [6]. We believe that supporting the social context of appropriative interactions by introducing visible affordances and facilitating their use is an important step for fostering appropriation. We summon that successful implementation of appropriation-enabling systems calls for multiple appropriation support structures. Thus our third approach to solving the challenge of "supporting appropriative behavior" is to provide multiple levels of appropriation support, including community support, interfaces for modification and collaborative change of software functions.

Designed for appropriation

To illustrate the previously presented framework for introducing appropriative affordances into the design of systems and services, we now introduce Dippler, a pedagogically engaged third generation TEL system [15], [16]. Third generation TEL systems are open and evolving Digital Learning Ecosystems, a concept that has been proposed by several researchers in the TEL domain. When, like it happens with Dippler, the ecological concepts are not used as a metaphor but rather extended into the digital realm, then the result is a an open, loosely coupled, self-organized and emergent digital learning ecosystem. The figure below illustrates the architecture of Dippler, consisting of a single centralised middleware application BackOffice Service (BOS), which is accessed by three types of client applications: teachers use institutional client to design and manage courses while learners use either a personal blog enhanced with a Dippler plugin or a mobile client. Several services can be integrated into the ecosystem as demonstrated by connecting the Question and Test Interoperability specification compliant quiz tool Questr, which is used for deploying test and self-test tasks. Such architecture allows the learner to host her personal learning environment wherever preferred, independently of course provider.

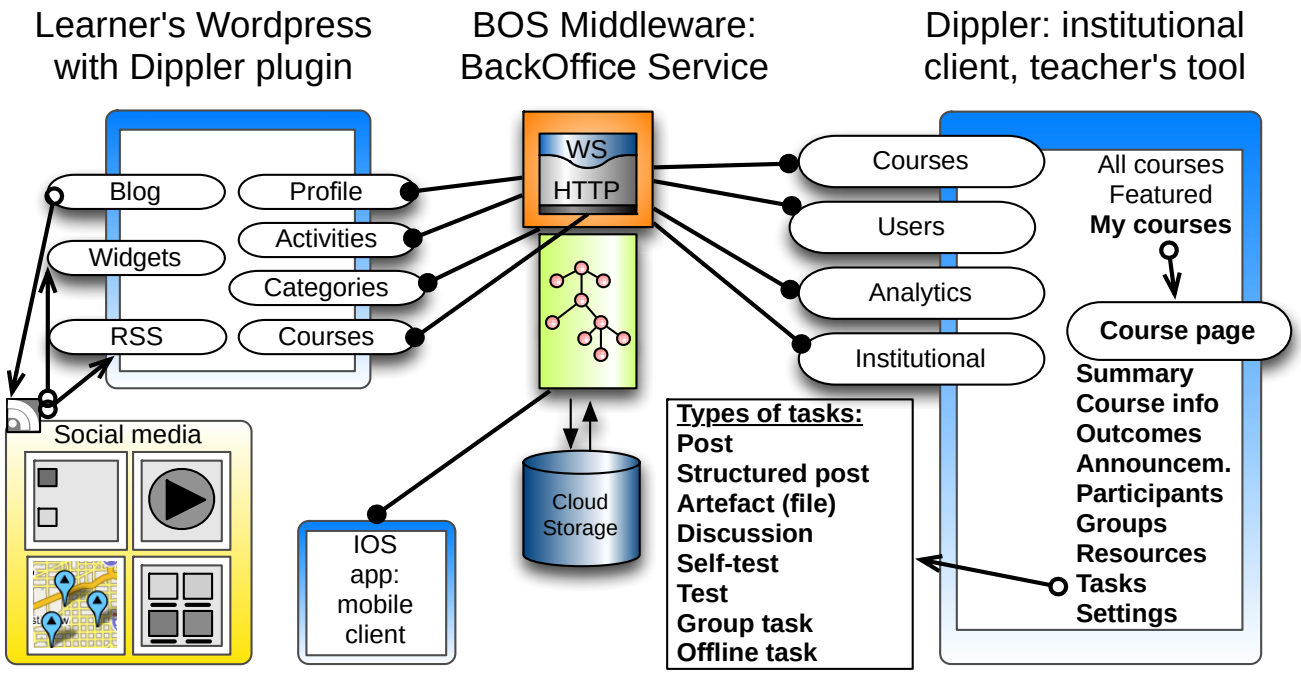

Figure 1. Dippler's main components

Dippler's design approach combines the visions gathered from participatory design sessions involving users with design concepts and decisions derived from the foundations of Digital Learning Ecosystems. The three main structural components of Dippler's design framework are: Software architecture: software elements, relations among them and properties of both; Affordances: functionalities and process models designed into user interface, invoking certain activities of users; and Vocabulary: metaphors and concepts implemented in user interface, which we will now relate with appropriation-enabling design approaches introduced before.

Cater for component-based tailorability and extensibility

This appropriation-enabling design challenge is adequately addressed in Dippler's design strategy through specific emphasis on an open, loosely coupled, self-organized architecture that was assumed as a goal from the beginning, thus facilitating the system's appropriation by those who wish to drift from the initial and assumed pedagogical commitments and intended workflows. Actually, not only the overall system

architecture facilitates repurposing, enabling usages that were not initially anticipated, but it also promotes high levels of customization and extendibility.

Support seamless integration into artifacts in use
Dippler's community mainly interacts with the system using personal blogs or mobile devices. It can be argued that this system allows its users to complete the work of the designers by the system's functionality into the scope of their situated activity, thus effectively integrating Dippler's artifacts in their own routines and facilitating the reconfiguration of their individual practices through familiar interfaces. Although partially resulting from the system's architecture, the seamless integration of Dippler into artifacts in use, such as the personal blogs or mobile devices, is also explicitly promoted in Dippler's design strategy as focusing on specific desired affordances.

Provide multiple levels of appropriation support
Finally, we argue that Dippler also succeeds on providing multiple levels of appropriation support as it also supports the social context of appropriations, promoted in this case by the use of personal but open interaction spaces – the blogs – freely accessible by all, thus raising appropriation awareness and facilitating collaborative change of software functions.

Discussion

To date, published work on *appropriation for sustainability* has mainly focused on describing appropriative uses of physical materials in everyday life in order to understand the phenomenon and lacks "guides to tangible action". However, *appropriation research* per se is abundant in HCI, CSCW, and IS (Information Systems) domains and has covered social as well as technical aspects of this phenomenon. Though the initial explorations on appropriation for sustainability through the study of the use of physical artefacts are a good starting point for discussions on the subject, we believe that the HCI knowledgebase is also well equipped to address the appropriation of software artefacts, including those which, due to their design, may lead to longevity of hardware artefacts on which they operate. Explorations in this direction could inform the need for the design of computing artefacts that foresee and scaffold users' activities by employing design principles that promote renewability and re-use of the digital artefacts through appropriation-enabling functions and signifiers. Thus, in this abstract, we have tackled one of the main SID principles outlined by Blevis, namely, creating opportunities of renewability and re-use for decelerating cycles of invention and disposal. As illustrated by Dippler's example, appropriation-enabling design challenges can in fact be addressed, to some extent, by fostering our proposed solutions. After this exercise we admit that there is still not enough evidence to support a claim for promoting sustainability of hardware artifacts by incorporating appropriation-enabling features into the software solutions. However, the results achieved by relating certain appropriation-centric design criteria to system design support the notion that appropriation-enabling affordances, if introduced in the design of software artefacts, can in fact influence attitudes of system designers and end-users on renewability and reuse. Future work on this direction would include development and validation of criteria for evaluating possible effects of appropriation-enabling features in software on the practices of shared and prolonged use, as well as renewability and re-use of hardware artefacts.

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