Device Ecology Mapper: A Tool for Studying Users' Ecosystems of Interactive Artifacts

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Abstract
This paper presents a tool for both researchers and designers called the Device Ecology Mapper, which allows users to share devices they own and describe to researchers how they *believe* these devices are connected. We built this tool from the theoretical perspective of ecology of artifacts in which designed artifacts do not exist independently, but rather in complex ecosystems with other artifacts through physical and perceptual connections. We designed the evaluations of this tool to evaluate the extent to which designers found the tool valuable and users found the tool true to the way they understand their ecology of interactive artifacts—rather than how closely user's perception of their ecology represents how these devices are actually connected. We found evidence for both perspectives from these studies.

Keywords
Digital interactive artifact, ecology, personal ecosystem, design, user research

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Early HCI research focused on the individual user interacting with a single digital interactive artifact. We

can also consider the way in which each individual utilizes his or her own heterogeneous system to cope with everyday life. This is the position our research group takes with respect to the technology we own or use. We call this phenomenon an ecology of interactive artifacts [7] where each technology we use, own, or have access to contributes to an intricate web of technology that influence buy new technology or manage our personal information and data.

We argue that this ecology has implications for the design of technology as artifacts compete for an ever crowded piece of our users' attention [8]. Therefore, the purpose of our research is to find ways to gather information about what artifacts users have and how they perceive them to be related as well as how this information can be integrated into future designs. To this end, we believe that one extension of our ecology of artifacts should involve collecting this information to aid the design community for dealing with ecologies of interactive artifacts. In this paper, we will discuss the theoretical background of the notion of ecology of interactive artifacts, the evolution of the design of the tool for capturing this data, an evaluation by both end users and designers, and future work on this tool.

Theoretical Background

The notion of personal ecosystems of artifacts appears in a variety of forms elsewhere. [11] describe the concept of device ensembles where one considers the user experience as an orchestration of many different devices working together to accomplish some task. They admit that although some devices will start to merge together as cell phones have begun to do recently, special-purpose devices will continue to have a role in the consumer market. While [11] presents a technical model of device ensembles, [5] presents a framework of product ecologies through the level of user experience. She describes product ecologies as an interrelated system of products, people, activities, places, and contexts of use. This model emphasizes how altering aspects of an ecology can alter technical and social relationships amongst users. The example in her study is the social changes that happen when a new family adopts the Roomba. Along these same lines, [1] present a system that goes beyond ubiquitous technology, but rather towards an environment that is interconnected with a group of devices to engage senior citizens with their community center.

In another example, [6] describe the rise of computational ecosystems as part of the transformation that is occurring in interactive technology. They raise issues of changing social views of technology, ecosystem maintenance, and information sharing. Finally, [4] present a study of twenty seven participants use and interaction with their devices. Most notably, they find that the association of a user's activities to any one particular device is problematic for users that own multiple devices and that to accomplish tasks users often assign roles to each of their devices [11].

From a designer's perspective, the need to understand a user's ecology is fundamental to the creation of new designs that work in these ecosystems. [9] describes the process of domestication of products through an ecology of goods perspective, which puts users in the midst of an autonomic system that balances the domestication of new technologies with voluntary choices made by users to adopt new technologies. [8] also describes the designer's role in manipulating these ecologies by conceptualizing the product environment.

He emphasizes how many consumers are unaware of how a new device may interact with their current product environment, which necessitates designers' involvement in guiding consumer choices. Finally, Cockton [2] argues that designers should consider how worth factors into buying patterns of new technologies by studying user motivations. A perspective of ecologies can help designers gain insight into issues of worth, value, and lifestyle that influence buying patterns.

We will not attempt to explicate the full theoretical framework of our research here (see [7] for a more in depth discussion of the underlying framework). We will, however, share a portion of the framework that is relevant to the current design. The essential units are *persons, artifacts,* and *contexts of use*. We identify *artifacts* in this study specifically as devices that a *person* owns, uses, or has access that are both digital and interactive. Also, for this study, we isolate the *contexts of use* as being part of one's *personal* ecology of artifacts.

Our model differs from these prior research efforts for several reasons. We focus on user's perception of the devices that they own and not so much the technical validity of their map. Also, we attempt to allow users an opportunity to understand their own role in their ecology by seeing the whole ecology—our level of analysis is the ecology not individual artifacts. There are some shared similarities with [5]; however, we feel that the approaches we take differ.

DESIGN

For our study, we wanted to design a tool or method for learning about user's artifact ecosystems, which may be unclear even to the users themselves. Consolvo et al. [3] describe a number of accepted user study techniques including contextual field research, intensive interviewing, usability testing, and lag sequential analysis. We seek new methods, however, to study this phenomena because of our desire to capture an individual's experience of their ecologies. In [7], we describe *personal inventories* and *ecology mapping* as suitable approaches to this problem. Simultaneously, we have constructed this tool called a Device Ecology Mapper to introduce the notion of ecosystems of artifacts to user groups[1]. An automated approach will allow us to collect vast amounts of ecology data, while still conducting in depth *ecology mapping* studies face to face.

Ecology mapping is a concept similar to *network sketching* as described in [10], which asks how users *perceive* their home computer network. They differ because while [10] were concerned with physical connections, we were also concerned with perceptual and emotional connections. *Ecology mapping* begins with spatially arranging artifacts. Connections are made between the artifacts to show relationships that may or may not relate to physical reality, but do represent a user's perception of these relationships. Finally, both artifacts and connections are value-laden so that an individual can have many different types of connections. This was incorporated by allowing different types of connections in which we used the *artifact properties* described in the next section.

[1] Theoretically, we refer to individual technologies as artifacts. For participants in our study, we refer to them as devices.

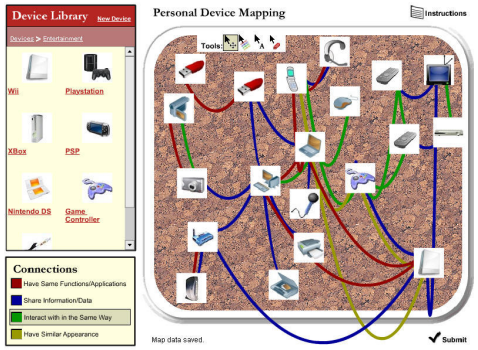

figure 1. One author's personal artifact ecosystem using the device ecology mapper.

With these goals in mind, we went through three design phases. In the first phase, we collected and analyzed sources of inspiration for our design. We wanted to distill core features and representations that could be included in the interface. We led a free form activity with 3 participants that provided minimal instruction (e.g., "please describe the devices that you own, use, or have access to and show how they are connected.") to see how people would choose to represent them. From this phase, we learned that each participant had a different mapping style, but had a common spatial and graphical organization. Seeing the drawings indicated that the direction should be graphical and allow for an organization of ideas. Finally, we came up with five concepts ranging from a pictorial node and edge diagram, premade clusters of devices, puzzle pieces to connect nodes, an isometric model of a 3D home, and a Facebook application where users "friend" their devices together. We ultimately chose the first because it was clearest for mapping the entire ecology at once.

In the second phase, we created a low fidelity prototype and tested our idea on 5 different participants. The new model used the metaphor of pinning devices on a corkboard and connecting them using pieces of yarn. This metaphor was chosen because of its less intimidating interface, rather than a more sterile version that is just an empty rectangle, while still maintaining the organizational qualities we deemed important from the previous phase. To make the prototype, we used a printout of a corkboard, small sample device cut outs, and actual pieces of yarn to connect them. We also clearly distinguished connection types by the yarn color used. The most prominent issues that were addressed in the next iteration were that the language in general contained too much HCI jargon for non-HCI users, the connection types were unclear, and the search bar needed to be changed to a category listing thus relying more on recognition of devices than recall. From participants' responses, it was clear already that they enjoyed working at the level of ecologies even if the interface still needed work.

Finally, we created a high fidelity prototype (see figure 1) using Adobe Flash. The design was made to be completed autonomously, although the evaluation for this paper was done in person. The device contained three main sections. First, users browsed through a categorized list of devices using the *device library*. Second, once found a device was added to the corkboard by clicking on it once. An icon was placed then in the top left corner of the *corkboard*. Third, the user had four *tools* to choose from on the board, which were located on the top left corner of the board. They could move a device around, add a connection, add an annotation, or delete either a device or connection. Finally, users selected the type of connection they wished to make on the *corkboard* using the *connections panel* in the bottom left corner. Connections were added when users clicked and dragged between two devices. The connections included four types of *artifact properties* including functional (red), informational (blue), interactive (green), and physical (yellow). Using this application, we evaluated the fidelity that this tool had to how the user understood their ecology of interactive artifacts and the significance of the tool and the information it collects for designers.

EVALUATION

We ran this evaluation with eleven total participants (7 men, 4 women). We looked for perspectives on language, conceptual clarity, and interactivity

effectiveness. Since we claim the capacity of this tool to collect information about users' ecologies will be useful for designers, six of these participants were design students (5 men, 1 woman).

User Evaluation

In this evaluation, we had people use the tool to map their ecologies. This was not a strict usability test, so we provided them with guidance for areas that they had questions about if they looked stuck. On average, users spent 17.4 minutes to place 20.18 devices, 39.18 connections, and 2.09 notes. The users were also asked several questions about their experience. When asked about their strategy for laying out the devices, each user had a unique strategy, although the most common strategy was to group around devices they believed were "core" to his or her ecology (4 participants). Users were also asked how they felt about the corkboard metaphor. Of those that responded, seven experienced it positively, while only two experienced it negatively and two had missing data. Few elaborated on their response, but those that did referred to the style of interaction.

When asked on a 5-point Likert scale how well the tool allowed them to map their ecosystem, participants responded with a mean of 3.55 (σ=1.13) with 1 being lowest showing that the tool worked well. Finally, several other questions provided perspectives on the positive and negative aspects of the tool. The positive aspects included an appreciation for the device library (3 participants) and interaction style (2), the visually appealing nature of the tool (1), and the capability of the tool to visualize what they had (7). Negative aspects included the space available on the board to layout devices (5), artifacts becoming too clustered (2), unavailable connections types (e.g., that two devices are connected when they are used at the same time) (3), clarity of instructions (2), and the learning curve (3). While there are some aspects of usability that could still be improved on, it seems like the tool was useful for the individuals to map their ecologies and even surprising in its ability to show them the high-level view they have not been able to see before, which several participants commented on positively.

Designer Evaluation

After a few weeks, we followed up with participants who were also HCI design students for a design perspective. In addition to the experiences they had n the study, we also sent them a screenshot of the ecosystem they constructed to jog their memories. Of the six who participated, only five responded. The first question asked was in what ways knowledge from the tool could positively or negatively affect their design activity. They described three key issues including visual sense-making (4 participants), function creep (3), and ecosystem complexity (3). Visual sense-making related to developing a situational awareness for the environment one is designing for as a positive effect. Function creep was mentioned as both a potential positive and negative effect. This arose over whether *needs* will be focused on from the tool or whether functionalities will be merged together even when they do not need to be. Finally, ecosystem complexity involved missing design opportunities because it may seem like all design problems have been solved or that further clarification was not available from the user. We also inquired about the importance of the concept of ecologies. Participants were positive about it stating that it reminds designers that they must accommodate what users already use

and what their lifestyles are, that it helps them understand trends avoiding pitfalls or "recreating the wheel" of other designs, and that it shows how new technologies emerge (seen also [9]).

Our evaluation reveals an effective design as well as room for improvement on future iterations. We found that the tool, while not directed for end user's use, was effective for people to share their ecologies, and was even useful for gaining new perspective on the devices they own. We also found indications that designers could find this collected knowledge useful to better understand the users they are designing for.

Conclusion

This paper presents a tool called the Device Ecology Mapper that leverages the analytical lens of ecology of artifacts. It provides information about a designer's audience related to the environment that is being designed for. The tool allows designers to visually situate new designs into what users already have access to, own, or use to avoid feature creep, understand technology trends in a user group, and to analyze what artifacts evolve and become domesticated into users' lifestyles. From this evidence, it seems like the information this tool can provide has potential value. While there are many benefits to the use of such a system in design, there is still much future work yet to accomplish.

The future work that remains on this application includes responding to user requests for more space to layout artifacts and more options for connecting them. We also plan to explore what tools can help designers analyze, interpret, and understand this ecological data and make it readily usable for design.

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