Pen-and-Paper Interaction for Everyday Tasks

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Abstract: Pen-and-Paper interaction (PPI) has recently gained attention as a form of tangible interaction, where normal paper is used in combination with a digtial pen to allow interaction with computer systems. However, research regarding the application domains of PPI has yet been focussed on knowledge work, despite the highly mobile and casual nature of paper. We argue, that the overlooked domain of mundane or everyday tasks requires additional attention and adds special requirements to supporting technologies and infrastructures. This is grounded on a case study in the domain of shopping planning support.

1 Introduction

Even in the era of ever more powerful smartphones and PCs, traditional paper remains a ubiquitous artifact in our daily lives, ranging from casually taken notes in a meeting to highly formal documents, such as contracts. This is not just a coincidence: it has been shown that paper is not easily replaceable by digital systems due to its unique affordances, it rather coexists with digital systems in current work practices [SH03], inevitably leading to a medial breakdown when using paper and digital devices in combination. Applications combining the advantages of digital information processing and paper, like Butterflynet [YLK+06] and CoScribe [Ste09] to name just two examples, have recently attracted some attention. Such approaches use digital pen technology to bridge the digital-physical gap in the context of paper documents, allowing *Pen-and-Paper Interaction* (PPI) with a digital system.

However, current PPI based applications have almost systematically neglected the domain of mundane or everyday tasks. In contrast to the the domain of knowledge work, we define an *everyday task* to be a human activity not primarily concerned with the acquisition or manipulation of knowledge as a goal in itself. Domains of everyday tasks are for example shopping, sports or leisure, but not learning or research (although the boundary arguably might be blurry). Such everyday tasks are important aspects of our lives and systems designed to support them therefore require our attention in addition to systems supporting knowledge work tasks. We argue that the potential of using PPI in applications supporting everyday tasks has not yet been sufficiently explored. More specifically, the casual nature of such tasks demands infrastructural support exceeding the concepts found in contemporary PPI based applications. In order to gain insights into the infrastructural requirements

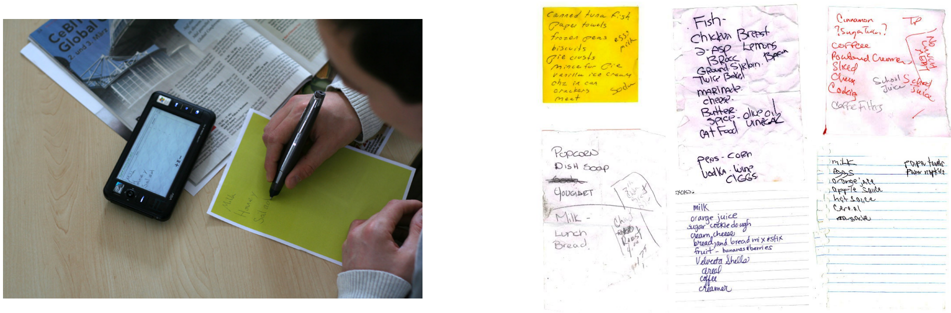

Figure 1: Typical shopping lists[1]

for PPI based systems supporting everyday tasks, we developed and analyzed such an application in a case study on grocery shopping support: the digital grocery list.

Studied Everyday Task: Planning Grocery Shopping The process of preparing and planning grocery shopping has been extensively examined in the consumer and retail research community, e.g., by Puccinelli et al. [PGG^{+}09]. In most cases, the planning phase for grocery shopping is quite extensive [TG04, BM99], while most households make use of grocery lists in the process [BBC08]. Such grocery lists are typically prepared either collaboratively, or by a person responsible for the need management of the household [BBC08]. The list-writer and the person performing the actual shopping are not necessarily the same, the grocery list is sometimes passed as a reminder to the actual shopper [BM99]. Block and Morwitz also found that there are not only need-based, but also financial incentives for assigning groceries to the list, i.e. coupons or bargain offers found in leaflets [BM99]. This means that these paper documents are also included in the shopping planing process.

Based on these findings, our own anecdotal evidence, resources on the web, and the ongoing use of paper leaflets by supermarket chains, we conjecture that paper plays an important role in the task of planning grocery shopping. The practice of using handwritten grocery lists is very common and intuitive: How many people you know have used a handwritten grocery list? How many have read a paper leaflet? Thus, a *Digital Grocery List* (DGL) application to support grocery shopping trips can serve as an exemplary application for the domain of everyday tasks clearly benefiting from PPI (see Figure 1).

2 THE DGL APPLICATION

As described above, planning of grocery shopping is typically performed on a household basis, where the actual shopper and the planner are not necessarily the same person. Therefore the digital grocery list is designed for collaboration: Using a mobile device,

[1] source: `http://www.grocerylists.org`

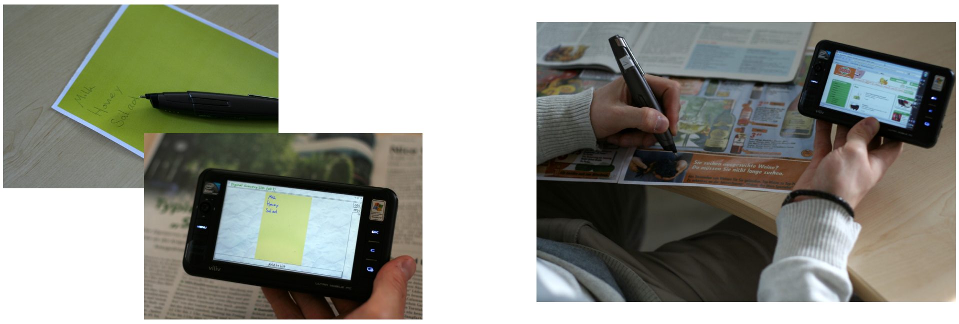

Figure 2: Specification of items using the digital ink facsimile and accessing of digital functionality directly in the leaflet.

everybody can manage items in a shared list. This list is stored on a server, accessible through the internet. In addition to managing the items in a GUI (as in typical shopping list applications for smartphones), the user may choose to use pen and paper for this task as the DGL is designed to support PPI.

Applications leveraging PPI mostly base on the Anoto[2] digital pen and paper technology, as it preserves many of the usage characteristics of regular paper (no calibration, no special hardware needed apart form the pen etc.). This technology has also been used to realize PPI in the DGL application. Here, items can also be added using PPI: The user writes items on a sheet of paper (augmented with the Anoto dot pattern) just like when using the traditional, paper-only grocery list. As shown in Fig. 2, a facsimile UI shows the items in the list and additional notes. Instantly visualizing the written ink helps users to understand the input they are providing to the system. Subsequently, the written items are attached to the grocery list in facsimile.

In addition to handwritten grocery lists, users browse leaflets and commercial brochures for preparing shopping trips. These documents essentially satisfy information needs, e.g. they tell the user which items are available as bargain offer. Therefore, DGL integrates these paper documents directly into the planing process: the user can select items in the leaflet by tapping them with the digital pen and thereby adds them to the grocery list. The mapping of the paper region to the item is controlled by a server run by the supermarket.

Customers consult leaflets searching for information about the products they need. However, the information in the leafleats may already be outdated and the supermarket may want to personalize the information. As of now, this can only be done using more interactive media, e.g. the web. However, the user experiences a media break when accessing the web, as she has to abandon her paper-based work and turn to a GUI. The DGL application is designed to overcome this break by allowing the supermarket to link web pages to paper documents. The user can access the web pages by activating hyperlinks on the leaflet with the digital pen as shown in Fig. 2.

In summary, the DGL application integrates hand-written shopping lists, paper leaflets

[2]http://www.anoto.com

distributed by the supermarket and instant digital feedback on a mobile device into one coherent system. We developed a Java Swing based prototype of these three components running on PCs (Microsoft Windows, Mac OS X and Unix). To emulate the mobile aspects, we deployed the applications also on a Viliv S5 UMPC (currently we are working on an Android version to be delpoyed on the Motorola Milestone). Backend connectivity, for example to the server managing the grocery list for a household or to the super market server managing the leaflet functionality, has been realized through the network middleware MundoCore [AKM07] and simulated using a WLAN.

3 SUPPORTING INFRASTRUCTURES FOR EVERYDAY TASKS

The DGL scenario reveals an important characteristic of PPI for everyday tasks: mobility. Paper is in itself a highyl mobile and robust medium, that allows not only to be carried and used easily in mobile situations, an aspect we refer to as *user mobility*, but also to be passed on between different parties potentially transgressing organizational boundaries, here denoted as *document mobility*. Consider for example the scenario where the super market distributes its leaflets to a range of potential customers, which must be immediately able to interact with the leaflets as part of their shopping planning process. From the perspective of the system employed at the customer side, this can be described as encountering a new document: the document has moved from one party to anotherone, hence the term *document mobility*. As a result, paper documents used in a task are not necessarily managed by a *single* authority but rather belong to *different* authorities.

User mobility takes the focus from the document to the user: the preparation of shopping lists is typically not done in a desktop setting, but rather in the kitchen or the living room, or even in a completely mobile setting. This requires the PPI infrastructure, to support interaction in a ubiquitous computing setting. Varying resources offering a diverse range of computational capabilities are typical for such settings, requiring a flexible approach regarding the deployment of application components. To save resources, multiple applications should be able to share parts of the processing of digital pen data. The infrastructure should further support to deploy these parts flexibly on different machines in a ubiquitous computing setting, e.g. process the raw pen data on the users mobile phone, while the main part of the application runs on a server somewhere in the house. One very important component which has to be part of the infrastructure and needs to be independent of the application is the management of documents and document regions. It must be implemented in an efficient way, permitting instant feedback, i.e. has to be available locally, while at the same time supporting document mobility, i.e. information from several different organization back-ends needs to be integrated.

An additional characteristic of everyday tasks is the weak structure of such tasks. There is no common process of generating a grocery list, although there are some common primitves which can be identified examining the process. In our setting, this is the concept of an item on the grocery list, or the existence of the list itself. As a result, support for such tasks is best realized using a small set of loosely coupled and interoperating applications exhibiting certain interfaces for interoperation, e.g. in the form of services. So the supporting infrastructure must allow several applications to *share* the same *resources*, e.g. the digital pen, and relate the interaction to the appropriate application (a leaflet application, a grocery list application etc.). This is even further corroborated by the fact, that most users would not spend a considerable amount of money on a digital pen, which would allow them only to write their grocery lists – yet if the pen would also support note-taking, paper reviewing etc. this might yield the appropriate incentive.

4 RELATED WORK

Existing applications integrating PPI are designed to support well structured tasks, in which a central authority manages all participating paper documents. In Butterflynet [YLK+06], the researcher manages her personal notebook at her office PC. In CoScribe [Ste09] all lecture materials are managed by the teaching personnel. *Document mobility* is not supported in these applications. Although [YLK+06] supports mobile use, its underlying infrastructure does not provide adequate support for *sharing resources* and the distribution of certain processing steps on available devices in the environment.

The PaperToolkit [YPK08] supports to some extent the distribution of processing steps, especially feedback channels, however, it does not allow *resource sharing* and does not provide mechanisms to provide *document mobility*. Existing infrastructures for PPI, like PADD [Gui03] and PapierCraft [LGH05], or iServer and iPaper [SN07], aim to address the problem of document mobility with a centralized client-server architecure. In PADD [Gui03] a central server allows to fetch the required application, which is processed locally. This centralized architecture, although solving the problem of document mobility on small scale, severly limits the scalability of the approach. *Resource Sharing* and *User Mobility* are not supported. In iServer and iPaper, a distributed hierarchical naming system for paper applications is used to locate the responsible server for an encountered paper document. Although this solves the problem of *document mobility*, this approach does not support neither *resource sharing* nor *user mobility* (Although there have been developed mobile applications based on the infrastructure [SNG+06]).

5 CONCLUSION AND FUTURE WORK

Everyday tasks remain an almost overlooked domain for Pen-and-Paper Interaction. We presented the DGL application as a case study for PPI based systems supporting everyday tasks. Compared to the domain of knowledge work, DGL showed that everyday task support poses new challenges on the underlying infrastructure: It needs to support *user mobility*, as well as *document mobility* and *resource sharing*. Existing toolkits and infrastructures do not provide sufficient support for these particular aspects of PPI. As a result we started developing a novel toolkit: *Letras*, which bases on a highly flexible distributed pipeline architecture. To foster the development of *Letras*, we aim to conduct further case studies for other interesting domains of everyday tasks involving PPI.

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