ActivityDesk: Multi-Device Configuration Work using an Interactive Desk

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Figure 1: The (1) desktop application, (2) tablet resource viewer and (3) ActivityDesk application.

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Abstract
Recent studies have shown that knowledge workers are increasingly using multiple devices, such as notebooks, tablets and smartphones to interact with different types of information that are part of their daily activities. Using multiple devices introduces a configuration overhead as users have to manually reconfigure all devices according to ongoing activities. Especially in an environment such as an office, where the use of multiple devices is more common, the process of configuring them in context of ongoing activities is cumbersome. In this paper, we present the initial explorations of the ActivityDesk system, an interactive desk that supports multi-device configuration work and workspace aggregation into a personal ad hoc smart space for knowledge workers. The main goal of ActivityDesk is to reduce the configuration work required to use multiple devices at the same time by using an interactive desk as a configuration space.

Keywords
Interactive Desk, Configuration Work, Multiple Devices

ACM Classification Keywords
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces, graphical user interfaces, windowing system

Introduction

Studies have shown that knowledge workers spend on average 30% of their work time outside their office [11]. Many computing devices, such as notebooks, tablets and smartphones facilitate this mobility greatly by allowing users to carry information with them. Rather than being tied to one environment, they allow people to roam between different places. Because of the different properties of these devices, users can tailor interaction with information according to the current context, situation or environment.

Recent studies [5, 9] confirm this trend and show that users increasingly use multiple devices to access information in office settings but in the meantime also struggle to manage this information as it is scattered across devices. As concluded by Dearman et al. [5]:

> *" Using multiple devices is increasingly the norm." However, "[..] participants reported that managing information across their devices as the worst part of using multiple devices."*

The device multiplicity and poor support for information exchange techniques and distributed workflows has increased the load on users as they are left with the burden of manually reconfiguring the devices based on the ongoing work context. Reconfiguration in this context refers to (i) finding the relevant documents and launching the correct application while moving or distributing work between one device to another device, (ii) dealing with interruptions generated by the different devices in use and (iii) updating the settings of a device. Especially, in an office setting, where the use of multiple devices is more common, the process of reconfiguring them in context of ongoing work is cumbersome because information and services are scattered across different devices.

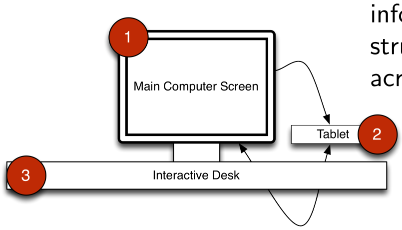

Figure 2: Devices can be used as (1) master, (2) slave or (3) mediator.

We introduce the ActivityDesk system (Figure 1), an interactive desk that supports (i) multi-device configuration work and (ii) workspace aggregation into a personal ad hoc smart space for knowledge workers. The main goal of ActivityDesk is to reduce the reconfiguration work required to use multiple devices at the same time by using an interactive desk as a configuration space. In this paper, we describe the motivation for this work through an exploratory field study of the use of desks and the initial user-centric design of the ActivityDesk system.

Multi-Device Configuration Work

Configuration work is the amount of work required to set up an environment so it enables the user to perform a task or activity. It is the effort required to *control*, *manage* and *understand* information, applications and services that are distributed over all used devices. The reconfiguration problem when multitasking on a single device has already been recognized and widely addressed by a myriad of approaches. However, with the introduction of device multiplicity and multi-user interaction with information, this problem is greatly amplified.

Technological advances have lead to a myriad of approaches (including iLand [12], Gaia [6], Interactive Workspaces / iRos [8] and Impromptu [4]) that deal with information exchange between displays and devices in complex smart space setups. In contrast to these systems, in which the central focus is on the interaction with applications and services across devices, we propose the use of *activity* [2, 7] as a central configuration mechanism that can be used across devices.

Activity is a description of a work context (including files, applications and other meta information) that is a reflection of the real ongoing activity of the user. By

Figure 3: A selection of desks used for the analysis.

making all used devices activity aware, activities can span different devices and thus form one *activity system*. Similarly, prior work has tried to reduce the reconfiguration overhead by representing and structuring the ongoing work context into tasks or activities. The majority of related work focuses on the configuration or re-framing of the desktop interface [7] but more recently the approach has also been applied to distributed user interfaces and pervasive computing [2]. The focus of these approaches are set on a per-device configuration of information. However, the concept of activities has the potential to transcend the device and be used as a mechanism to relate and structure distributed information, services and interruptions.

The *role* of a device can play an important factor in supporting personal workflow [5] as it allows the device to adapt to the situation based on a specific configuration. A tablet computer could e.g. be used as the main device when moving from or to the office or when participating in a meeting. When the device, however, is imported into the office and put on the desk, the tablet may become secondary to another device and thus extend the digital workspace of the main device. Additionally, the type of device plays an important factor in determining its role. While tablets, smart phones and notebooks are an excellent candidate for both master and slave role, there is also the potential for devices to play a mediating role. An interactive table e.g. has the potential of replacing paper documents but also to be used as a mediator between other devices that are placed on the table.

We thus envision three types of device roles: (i) master, (ii) slave and (iii) mediator (Figure 2). A master device holds control of a specific environment as it has the central focus of the user. In an office environment, this is typically a stationary desktop computer or notebook. Since the master device has the focus of the user, any other device in the space is a slave, that is linked to the main device and serves as an extension to the periphery of the main device. The mediator finally, is used to facilitate, visualize or manage the connection between a master and slave device. Note that any device can hold multiple roles and evolve from one role to another based on the configuration of the user or predefined rules.

Interactive Desk

Exploratory Field Study

During an exploratory field study, we performed a contextual inquiry as well as an analysis of the desk space of 15 knowledge workers (Figure 3). The study showed that many participants use multiple devices in their office setting (including tablets, notebooks and phones) but also peripherals to extend screen space. Participants also seem to use these devices as part of the same general activity. Especially the tablet computer seems a popular device for use in combination with a desktop computer or notebook.

Participants claimed high ownership over their desk. The arrangement of artefacts and devices on the desk was highly personal but differed slightly between different participants. All desks could be abstracted into a meta-desk (Figure 4) that consists of two planes with different zones. First, the visualisation plane is used for the output of interaction on the desk. Participants seemed to use external screens to widen the periphery and argued that the added screen space helped them configure the different applications they are using. Second, the interaction plane (or the desk itself) consists of three different zones: (i) storage and archiving zone, (ii) input and interaction zone and (iii) the active space.

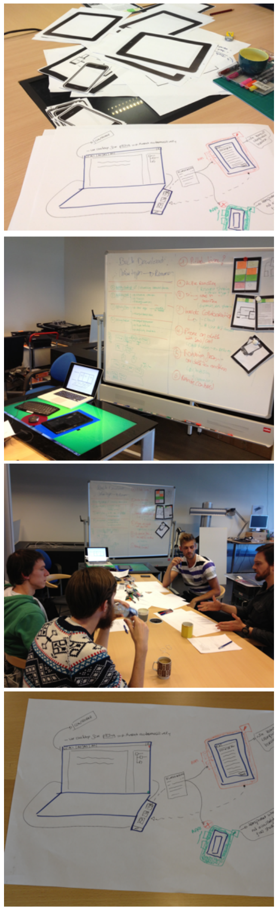

Figure 5: The desk was designed through a user-centric design process involving a number of knowledge workers.

The storage and archiving zone is primarily used to store documents, objects or other artefacts that are not used. The input and interaction zone is a space that is used for input devices such as a mouse or keyboard but also for physical input devices such as pens, markers or pencils that are used in conjunction with notebooks and post-its. Additionally, this space is also used to store and use mobile devices such as tablets or mobile phones. Finally, the active zone is the space right in front of the user that is used for highly focused work. The artefacts in this zone are objects and tools brought over from the other zones.

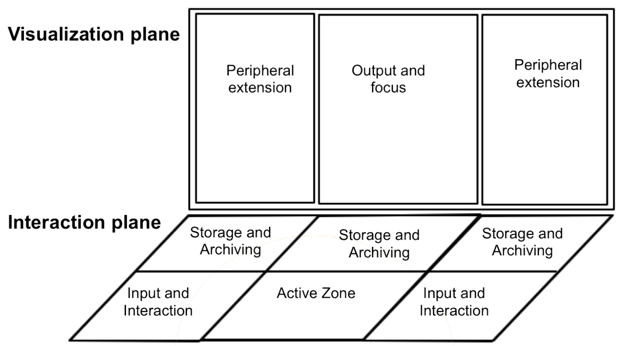

Figure 4: The zones defined in this meta-desk were found in all analysed desks.

Previous studies and our exploratory field study show that modern knowledge work is composed of both (i) mobile (or nomadic) work, which refers to a scenario where the users move between locations while doing work, and (ii) stationary work, in which the user uses a space over which they claim ownership. In the latter context, whe work desk seems to play an important role in managing documents, devices and artefacts related to knowledge work. Our purpose is to design a system that allows users to seamlessly move devices between a nomadic and stationary context by using the office desk as an interactive mediating device.

Similar observations have been made in prior work which explored how tabletops or augmented desks can be used to (i) expand the screen space to a broader periphery [14], (ii) include support for real objects and artefacts [1], (iii) create aggregated information spaces [3, 10] or (iv) support multi-plane desktop interaction [13]. ActivityDesk builds on this prior work to explore the *usefulness* and *impact* of an activity-centric approach to the multi-device configuration problem.

Based on the field study and prior work, we conducted 3 participatory design workshops with 5 knowledge workers to co-design the interactive desk and applications for notebook and tablet to interact with the desk. During the workshops, we used a scenario-based approach as a starting point for paper-based mockups (designed by participants), that were discussed and evaluated. The last workshop also included a technology probe, to spark discussion on previous designs and expose participants to the actual technology (Figure 5).

ActivityDesk

The current prototype consists of the interactive table (a Microsoft Pixelsense [1] mounted in a normal desk) running the ActivityDesk (Figure 6) application, and a notebook and tablet. When the user places a notebook or tablet on the desk, it will attempt to pair with the recognized device and start a new activity session. Removing the device will stop the session and remove all shared information or resources on the desk. The desk is thus a semi-public mediator and configuration space that can be used by different people.

[1] http://www.microsoft.com/en-us/pixelsense

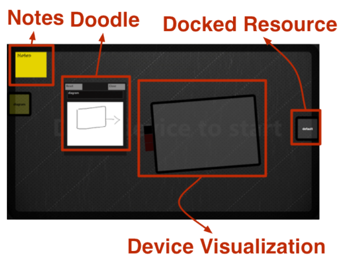

Figure 6: The anatomy of the bare ActivityDesk system.

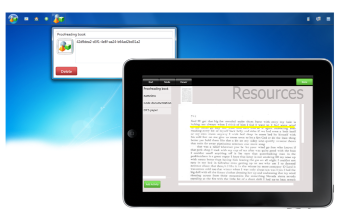

Figure 7: The desktop activity bar and resource viewer on the tablet.

Figure 8: Managing deployed resources on the desk.

The notebook runs an activity manager (Figure 7) that visualizes ongoing activities on a taskbar [7]. Each activity is assigned to a dedicated virtual desktop, which contains all files and applications that are part of that activity. Adding files to the active desktop workspace will add them to the ongoing activity and clicking an activity button on the taskbar updates the working context to the appropriate virtual desktop and/or all other connected devices. The tablet (Figure 7) is equipped with an *active reading*, *resource viewer* and an *image editing* application. Each application is activity-aware, and has the ability to interpret and visualize resources (documents, images and activities themselves).

When the desk successfully pairs with a notebook or tablet, it will display the resources (documents) that are marked on the detected devices as *shared*, and allow the users to interact with them. Adding additional devices (that can be recognized and are authorized) will add them to the ongoing activity. All connected devices are merged into one workspace (activity system) with access to all shared resources and services. To allow for local mobility, a paired device can be pinned to the desk. By clicking a button on the side of the visualisation of the detected device, the resources remain shared on the desk, but the device can be physically removed from the desk without losing the connection. A thumbnail representing the device is added to the table to indicate a still open connection with the device.

The desk can be used for multiple purposes. First of all, it functions as an *extension* of the workspace of the users, as it allows users to move documents and resources to a large surface (Figure 8). The multi-touch desk includes the ability to annotate documents, create to-do notes or doodles, or simply organize documents in activities. In addition, to facilitate interaction with large amounts of resources, users can dock resources to the side of the desk causing the desk to only show a thumbnail and short name for overview.

Second, the desk can be used to engage in cross-device resource management as users can simply drag and drop files between devices, using the table. When the user drags e.g. a pdf file to the tablet, the built-in activity manager will propose a number of applications that can handle that particular resource. The user can then select an application by clicking the appropriate button on the desk. In this mode, the desk is used for meta- or configuration work, which refers to setting up the device for use in a particular activity.

Finally, the desk can be used to select input mode. All devices that have the ability (and are configured) to share input devices can be connected through the activity session. This means that multi-touch input of the tablet application can e.g. be redirected to the desktop system.

The ActivityDesk system is built on top of an infrastructure, that is composed of a number of cloud- and local distributed activity services (including file syncing, HTTP REST publish/subscribe event system, bonjour discovery and a distributed UDP context processor). Each device has an activity client installed that hooks into these services and thus allows the device to become activity-aware. For long term persistence and distributed collaboration, the local activity information is replicated into a cloud-service and exposed through a web service. All activity related events (CRUD [2], discovery, device added,...) are automatically distributed to all devices that are connected to a local activity system.

[2]Create, Read, Update and Delete

Future Work

We presented the initial explorations of the ActivityDesk system, an activity-centric interactive desk that supports multi-device configuration work and workspace aggregation into a personal ad hoc smart space for knowledge workers. We are currently in the process of evaluating and refining the design of the first iteration of the prototype. We hypothesize that by using activities as a *configuration mechanism* and the interactive desk as *configuration space*, there will be a decrease in overhead when using multiple devices in a personal working context. However, we are also interested in side effects of the use of an interactive desk such as the positioning of devices, the possibilities of using the extra screen real estate and the perception of the user towards an interactive desk.

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