Augmenting Tabletop Design for Computer-Supported Cooperative Work

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With the development of novel tabletop technologies there is also a growing research interest in cooperative work with interactive tables. This paper presents an analysis of the different kinds of traditional tables that exist in an office environment. The tables' relation to the range of activities that they afford and support are discussed. Concluding from this, design issues for interactive tables and their corresponding software are brought up together with examples from the body of research on interactive tables as well as potential research directions for the future.

Research Vision

The use of dedicated tables in cooperative work situations predates that of computing technologies by far. Even today, as the digital revolution has already happened in many areas of human life, cooperative work is still dominated by traditional media. In most instances, work meetings are still being held without computer-support for the entire group, whereas laptops or PDAs are already established to support individual activities. However, the collaborative activities of the group members gathered around the tables in the meeting rooms are much more important in the context of cooperative work. What kind of collaborative activities are tables used for? If we regard the typical collaborative uses of traditional tables, we find a rather heterogeneous pattern of activities that is highly dependent on the actual form of the table as well as its position in the architecture of the place. We can – at least – differentiate between three types of tables with different purposes and supported activities. They are briefly and prototypically defined below. Of course, there are probably more types and usages of tables with more different purposes, but in the context of collaborative work they are frequently found.

Meeting-Table

The first and most prominent table is the *meeting-table* (see fig. 1). Several (sometimes many) people sit around a meeting-table for a certain amount of time; their primary activities are related to communication, e.g. negotiation or giving reports. Every participant usually has a defined private space on the table where she can e.g. take or pile notes on paper or use a laptop computer. The public space in the center of the table is used for public artefacts such as cans of coffee or biscuits and only sometimes serves as a shared workspace, e.g. for clustering cards or creating a large Mind-Map structure. With a growing amount of participants the activities related to communication usually become far more important than anything related to the creation of a shared artefact on the table's surface. For a meeting-table it thus seems to be crucial to support activities related to communication, i.e. one primarily has to facilitate individual actions for storing and receiving information. The presentation of group-related information on the table is less important: Due to the different viewing angles the presentation of such information is usually shifted away from the table to a wall-sized display, a flip-chart or a Metaplan-board.

Figure 1: Two examples of typical meeting-tables

Collaboration-Table

In contrast to the meeting-table the *collaboration-table* is not primarily geared towards communication, but it emphasizes actually working with or on the table's surface (see figure 2). It is commonly used by fewer collaborating people at the same time than the meeting-table. Also, to raise the activation level of participants they often stand around the table in contrast to sitting. Consequently, the duration of work-periods with the collaboration-table is usually shorter than with meeting-tables.

Figure 2: Two examples of typical collaboration-tables.

When using a collaboration-table the main focus of attention lies on the public surface of the table that holds a shared artefact such as an architectural plan or a geographical map ("commander's table"). Accordingly, there are no or hardly any private spaces on the table's surface. Since working with the collaboration-table focuses on actual collaborative activities related to the shared public artefact, there are more issues to support properly than with the meeting-table. Most importantly, when working on a collaboration-table it must be ensured that all the participants of the work session have equal access to manipulation and retrieval techniques of information on the public surface. This implies that the viewing angles of all the participants are taken into account so that the orientations of information objects become somehow adjustable or that differences in viewing angles are compensated in any other way. Also, one of the reasons why traditional collaboration-tables are used is that they allow working in parallel and thus can prevent the effects of *production blocking*. For a computer-augmented collaboration-table it is therefore important to also allow simultaneous manipulation of the shared workspace.

Ambient Table

The final and frequently forgotten kind of table might become one of the most important room elements for the knowledge worker of the future. The small *ambient table* can be found distributed in all kinds of public places inside an office building. In addition to large public walls it is a very important piece of furniture that is available for the support of informal, opportunistic encounters and quick ad-hoc work for small groups. Its position in hallways, in the lobby, or in the cafeteria affords its lean shape that allows only two or three co-workers to stand around it and perform *any kind of activity* that might emerge from the circumstances of the given opportunistic encounter (see fig. 3).

Figure 3: Two examples of typical ambient tables

Since the ambient table is mainly defined by its ubiquitous availability in unplanned work situations, it must cover a broader range of activities than those tables that have a more designated purpose like the meeting-table or the collaboration-table. Also, data access and privacy are more central issues than with the other tables, because of its unique position in the architectural space: In contrast to public walls the work on a public ambient table is in most cases of private nature. But the ambient table itself, in contrast to the other tables described above, is a completely public artefact that must not leave any traces of the private work behind. Thus, means of importing and exporting information are as crucial for an ambient table as the availability of a broad range of applications. However, because of the unplanned nature of the interaction with the ambient table, one can not assume that the participants of an informal meeting at an ambient table have all the relevant data with them (if they knew of the work session beforehand, they could have met at the meeting room). In addition to means of interaction, it is therefore especially important to provide multiple ways of data import and export both using physical information carriers and network/ internet support including temporary access to personal folders (which in turn requires support for user authentication). Other types of tables are usually embedded within designated spaces such as meeting rooms where issues of authentication or data transfer are handled more globally, e.g. for the entire room.

As noted above, there are probably more types of traditional tables; and also among interactive tables we can find completely unique forms and techniques of tabletop realizations (Tandler et al, 2001). But even if we stick to the three types of tables described above, it becomes clear that table interfaces and functionality need to be highly adaptive to the properties of the tables and their primary use. For two people meeting at an ambient table we might get along well without parallel interaction on the table's surface, since they will most likely transfer the turn-taking style of their oral dialogue to their work on the surface. Also, for a big meeting at a meeting-table with lots of talk and little collaborative interaction besides, it is probably more important to support a decent scribble interface for private note-taking than methods for making a shared structure well perceivable for any single participant.

Adaptation of Interaction Design

So we need interaction designs that are not only adapted for tables (in contrast to desktops or walls), but also adapted for *different* tables and activities. Until today, there does not seem to be a general user interface system that covers all the different types of tables and types of activities equally well. For instance, Shen et al. (2001) present a very well designed system to deal with a large shared space of images that even supports private spaces and takes completely arbitrary viewing angles into account. The underlying interaction principles are most appropriate for many tasks on a collaboration-table (especially when used with multi-user touch displays, Dietz & Leigh 2001). However, for several situations on ambient tables one might want additional interaction objects such as scribbles. Streitz et al. (2001) have developed a groupware that especially addresses the adaptation of interfaces for different interactive room elements (so called Roomware®). For instance, it provides an interface for rotating objects on tabletop displays, but not on walls, because the viewing angle problem does not apply to walls. There are also several basic types of interaction objects such as scribbles, gestures, images, windows/ workspaces as well as more specialized modules built on top of these like Mind-Mapping or card-based creativity techniques (Prante, Magerkurth & Streitz 2002) that facilitate a rather broad range of applications (see fig. 4).

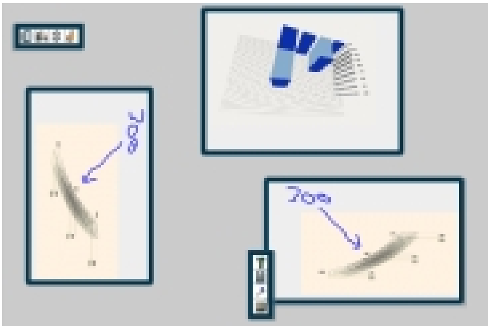

Figure 4: The BEACH groupware with rotated views

The issues of data import and export are also addressed with a token-based system that allows quick data transfer between room elements with arbitrary physical objects ("Passage"-mechanism, Streitz et al. 2001).
However, internet access, email export and other means of going beyond the infrastructure centric approach used here are not yet fully realized. Moreover, the most severe drawback lies in the missing capabilities to support multiple-users per device which is due to limitations with the hardware of the Roomware components so far developed. For instance, our collaboration-table InteracTable® is realized with an integrated touch-sensitive plasma-display (PDP) that supports only one pen at a time. It is, however, only a question of time until new hardware with multiple-user support will be integrated into Roomware components, so that collaboration in truly parallel work modes will be possible.

The Use of PDAs

To overcome the current problems of multiple users and to address other issues described above, we are currently investigating the use of personal digital assistants (PDAs) to augment the interaction with the InteracTable® and other Roomware components. For instance, we have developed a text input that allows entering characters on the PDA and perceiving them directly on the table's surface (Magerkurth & Tandler, 2002). Since we support multiple PDAs at the same time, users can work simultaneously (at least when they are dealing with text entry).

A more general approach to implement parallel work with multiple users was followed with PalmBeach (Magerkurth & Prante, 2001) which is a PDA application that allows working with most of the standard interaction objects found on the interactive tables and walls of our smart environment. Due to the private nature of the PDA's display, PalmBeach also addresses the realization of private workspaces that are important, e.g. with meeting-tables.

Finally, to deal with the problem of data transportation on ambient tables we are currently augmenting the passage-mechanism (Streitz et al., 2001) to make use of PDAs. We still allow the PDA to use the standard token-based authentication approach where the actual data is exchanged with a server in the background, which works well inside a smart environment and its provided IT infrastructure. To gain additional persistent storage functionality outside the environment we are also implementing a second method of generic data exchange, where the information is actually stored on the PDA using an infrared connection. This way, we can deal with more cases of opportunistic meetings on ambient tables, e.g. including a visitor from a different organization.

Our present observations are that the use of PDAs for the interaction with different types of tables is beneficial to overcome some of the problematic issues described above. What we have not yet achieved is the integration of our different PDA applications into one general tabletop-support-tool that adapts to the needs and affordances of the specific types of tables that we find in work environments.

Workshop Issues

Our expectations towards the workshop are to exchange thoughts with other researchers in the field of tabletop interaction and to get feedback on our PDA approaches as well as to progress on the task of creating appropriate user interfaces for multiple kinds of tables.

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Current Research Direction

The author's current research focuses on enriching the use of interactive tables (and other Roomware components such as walls or chairs) with additional devices like personal digital assistants, sensor boards, and physical tokens. The aim is to overcome some of the shortcomings addressed above and to further exploit the potential advantages of interactive media.

Authors’ Background

Carsten Magerkurth

Carsten Magerkurth studied Cognitive Sciences at the University of Mainz, Germany, where he earned his diploma in 2001. He then joined the AMBIENTE division of Fraunhofer IPSI, where his main research topics include the role of mobile and handheld devices in conjunction with larger systems such as interactive walls. He is Fraunhofer IPSI’s representative in the Ladenburger Kolleg “Living in a smart environment” of the Daimler-Benz foundation that deals with the social implications of future technologies.

Peter Tandler

Peter Tandler is a member of the AMBIENTE division of Fraunhofer IPSI since August 1997. He leads the software development within the BEACH and i-LAND projects.
His research interests are within the areas of synchronous CSCW, integration of virtual and physical environments, new forms of human- and team-computer-interaction for roomware components. Additionally, he is interested in software architecture, programming languages, object-oriented frameworks, and object-oriented design and programming in general. He is currently working on his Ph.D. in the context of application models and software infrastructure for Roomware environments.
He studied computer science at the Technical University of Darmstadt, Germany, with education and psychology as additional subjects.

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