# Reducing Clutter on Tabletop Groupware Systems with Tangible Drawers

**Björn Hartmann, Meredith Ringel Morris, Anthony Cassanego**
Stanford University HCI Group
Computer Science Department, Stanford, CA 94305-9035
{bjoern, merrie}@cs.stanford.edu, tonyc@stanford.edu

**ABSTRACT**

Simultaneously presenting multiple users' data on a single, shared display, such as an interactive tabletop, often results in visual clutter. One strategy to reduce clutter on horizontal surfaces in the physical world is to store objects in drawers. Items in drawers are hidden from view but are accessible when needed. Inspired by analogies with traditional desks and tables, we have developed tangible drawer mechanisms to augment a projected multi-user tabletop display. The drawers serve as dedicated input mechanisms to access, scroll through, and hide personal data. We describe our implementation and interaction techniques, and then report results from an informal pilot study.

**Keywords**

Tabletop interfaces, tangible interfaces, single display groupware, furniture user interfaces (FUIs).

## INTRODUCTION

Single display groupware often suffers from visual clutter. In collaborative activities private content, group content, and UI controls all have to compete for space on a limited surface. Clutter obscures relevant pieces of information with irrelevant ones, leading to increased search cost and cognitive overload.

On real desks, one strategy of containing clutter is to remove piles of paper, tools, and other artifacts from view and store them in drawers. Compartmentalizing (spatially multiplexing) the storage of work artifacts into separate chunks makes search more manageable and clears the main work surface. We decided to investigate drawers as an organizing technique for interactive tabletop displays because of their interesting properties: they are located in a predictable place within easy reach but separated from the plane of the desktop; they reveal on demand; they offer partial access (opening a bit vs. all the way); and they offer access restriction through their handle.

To explore the strengths and shortcomings of applying a physical drawer metaphor to a multi-user tabletop interface, we developed a prototype system that uses tangible drawer mechanisms to manage display of personal data.

## DRAWER HARDWARE

We used a top-projected DiamondTouch table which accepts touch input from up to four simultaneous users. We supplemented the table with four identical tangible drawers (one for each user). The drawer mechanisms were laser-cut from ⅛" acrylic (see Figure 1) and were attached to the bottom of the table surface at the left corner of each user's table edge – the place conventional drawers would occupy. Each mechanism has a drawer travel of 60mm. Position of each drawer is sensed through a Panasonic linear potentiometer mounted in the drawer frame. On the end facing the user, each drawer has a knob with a 300 degree range of motion. Rotation happens in the plane perpendicular to the sliding axis to ensure both controls can be used independently. Tangible input from the drawers is sent to the PC and processed using the d.tools toolkit [1]. Each drawer also has a USB dock to which a small USB flash drive can be connected.

## DRAWER INTERACTION

Users approach the table carrying their personal data on a USB flash drive. Inserting the flash drive into the dock of the drawer makes the user's data available for display.

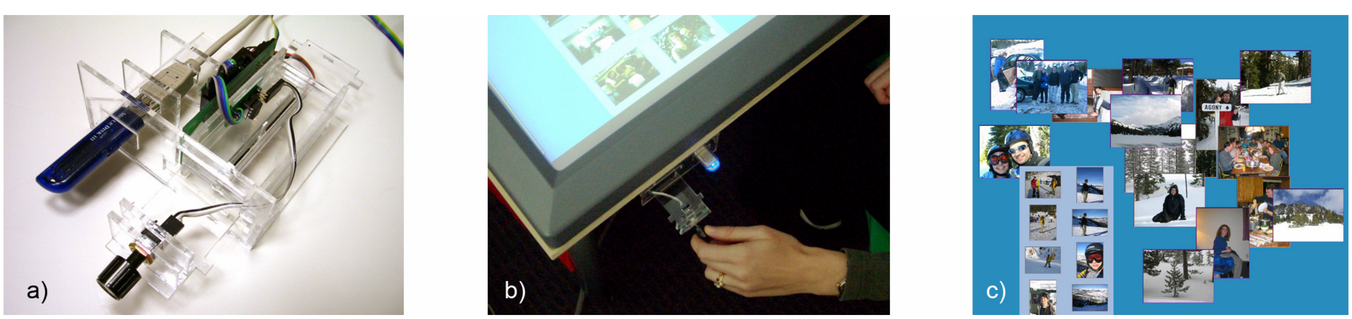


**Figure 1.** a) An acrylic drawer mechanism, connected to the PC via d.tools, affords pulling and pushing, as well as scrolling. The drawer has a slot for plugging in a USB flash drive. b) Four drawers are attached to the DiamondTouch table, one on each side. c) Pulling out the physical drawer handle opens a virtual drawer on-screen, which can be used to store data objects, such as the digital photos shown in the lower left corner here.

The physical affordances of the drawer are designed to make them simple and natural to use by leveraging people's existing knowledge of traditional furniture interactions. Pulling out the physical drawer handle towards the user opens a virtual drawer on the projected tabletop: items (*e.g.*, digital documents or widgets) contained on the flash drive are shown in a rectangular overlay on the table. By turning the physical knob on the drawer's handle, the contents of the virtual drawer can be scrolled horizontally, so as to create a larger storage space. Both pulling and scrolling are implemented as continuous actions with smooth animation, *e.g.*, drawers can be opened partially. Items can be dragged with a finger between the displayed drawer area and the main section of the table. Items are shown at reduced size in the drawer and expand automatically when dragged onto the table. Moving items between drawers and the tabletop results in file transfers between the table's host computer and the respective flash drive. In this way, the contents of drawers are portable across distinct table installations.

## INFORMAL EVALUATION

We conducted an informal pilot study with a group of three graduate students in our lab. The participants had recently returned from a shared trip. We collected their individual trip photographs, and chose 14 photos from each user's collection, which were placed onto their respective USB flash drives. After demonstrating the functionality of our drawers, we asked the group to create a photo collage to represent their trip using the drawers-augmented DiamondTouch table.

### Affordances

Users noted that the tangible drawer interface enabled bimanual interactions (one hand manipulating the drawer and another interacting elsewhere on the table). One user mentioned that because the drawer was physical, it was easy for him to find, and he didn't have to worry about it being obscured by other content on the table. One user noted that the inverse mapping of the drawer mechanism and projection (*i.e.*, pulling the drawer handle towards the user opens the projected drawer toward the center of the table) was confusing at first, but that he quickly got used to it. One user commented he felt "blind" to what was in his drawer, and suggested that making drawers more easily "glanceable" when opening them might help increase his awareness of drawer contents.

### Organization & Privacy

The table quickly became cluttered during the photo collage activity, and the group surprised us by commandeering the unutilized drawer on the fourth side of the table as a "trash can" – a place to put photos that they deemed irrelevant. This may be a digital analogy to junk drawers on normal desks. Users also made use of their drawers in a partially open state, to prevent the drawers themselves from cluttering the table. We were surprised to see that users reached into other people's virtual drawers, to remove or add content, despite the fact that we had associated drawers with individual ownership. Participants did comment, however, that they would not think of physically opening or closing other users' drawers, and indeed instead verbally requested these types of actions. This highlights different levels of intrusiveness attributed to actions that manipulate bits versus those that manipulate atoms.

## RELATED WORK

Using USB flash drives as tangible tokens of personal data was inspired by mediaBlocks [5]. A categorization of tabletop "territories" into personal, group, and storage classes was proposed in [4]. We contribute a novel solution that moves the access interface for a storage territory off the desktop. A design strategy to create individual copies of frequently used application tools near users' seats on tabletop groupware was proposed in [2]. Drawers work in accord with this suggestion by placing a dedicated tangible interface within easy reach at the table's edge. Storage bins [3] offer a space-saving technique for organizing sets of group content through moveable projected containers that are always present on the tabletop. Tangible drawers address a different point in the design space: they focus on private data storage that can be hidden when not required.

## CONCLUSION

Our initial observations of the tangible drawers system in use were encouraging, and suggest potential improvements for making drawers an effective technique for providing clutter reduction in a shared tabletop system, and as a natural metaphor for information sharing.

## ACKNOWLEDGMENTS

We thank our study participants and Mitsubishi Electric Research Laboratories for donating a DiamondTouch table.

## REFERENCES

1 Hartmann, B., S. R. Klemmer, M. Bernstein*, et al.* Reflective physical prototyping through integrated design, test, and analysis. In Proceedings of *UIST 2006: ACM Symposium on User Interface Software and Technology*, 2006.

2 Morris, M. R., A. Paepcke, T. Winograd, and J. Stamberger, TeamTag: exploring centralized versus replicated controls for co-located tabletop groupware. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*. 2006, ACM Press: Montréal, Québec, Canada.

3 Scott, S. D., M. Sheelagh, T. Carpendale, and S. Habelski. Storage Bins: Mobile Storage for Collaborative Tabletop Displays*. IEEE Comput. Graph. Appl.* **25**(4): IEEE Computer Society Press. pp. 58-65, 2005.

4 Scott, S. D., M. Sheelagh, T. Carpendale, and K. M. Inkpen, Territoriality in collaborative tabletop workspaces, in *Proceedings of the 2004 ACM conference on Computer supported cooperative work*. 2004, ACM Press: Chicago, Illinois, USA.

5 Ullmer, B., H. Ishii, and D. Glas, mediaBlocks: physical containers, transports, and controls for online media, in *Proceedings of the 25th annual conference on Computer graphics and interactive techniques*. 1998, ACM Press.