

Design Factors Affecting Synchronous Coordination in Large Groups using Cursors

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ABSTRACT

As the number of simultaneous users in a system increases, its ability to support coordination can begin to break down due to visual clutter, complexity, and organizational problems. We designed and observed the effects of five different interaction methods aimed at addressing these issues. We identified five factors that affect an interface's ability to engender coordination in large (10-20 users) groups. These included the clarity of functionality, existence of roles, visibility of state, explicit coordination process, and support of individual agency. Based on these results, we also present a model for framing coordination in such systems.

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General terms: Design, Human Factors

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INTRODUCTION

Recently, researchers have been experimenting with extending single-display groupware systems to support large groups (e.g. a classroom) [5]. This will allow a relatively large number of users to collaborate simultaneously presenting new opportunities to utilize group knowledge and to educate students. However, the potential benefits and issues of supporting large groups of co-present or distributed users have not been well-understood, primarily because of the resulting problems that arise in these interfaces. Researchers aim to control and study coordination and collaboration with such systems but current interfaces lack the right affordances to avoid the ensuing chaos. How can we address these problems in order to study the nature of large-group interaction?

There are several salient problems when 10-20 users simultaneously enter discrete mouse input into a single screen. First, visual clutter arises as each user's cursor has visual representation. Complexity also arises in an auditory sense when efforts to coordinate cause users to talk over one another,

often redundantly. Further, simply organizing a large group becomes a problem that is not naturally addressed for users in such systems.

In this work, coordination refers to task-related communication (auditory or visual) which "ensures that work progresses and redundant work is minimized" [2].

RELATED WORK

When considering the use of roles in multi-user systems, they should be flexible rather than pre-determined and permanent [7]. In order to reduce the visual clutter of many moving telepointers [3], Osawa combined cursors into an aggregate pointer, which showed the group's general intent [6]. Gutwin emphasized an individual's movements by rendering the line of each cursor's movement. This left a trace, like a footprint, that enhanced coordination [3]. Methods to support coordination in larger groups (10-30, distributed or co-located) have not been explored.

INTERACTION DESIGN

We designed and evaluated five methods aimed to support coordination in two categories: 1) defined roles for controlling on-screen objects and 2) no differentiated roles.

Defined Roles

Top-Down and Bottom-Up: Users can create, join and leave groups. Each group has two roles: leader and follower. In bottom-up, the leader controls the movement of an aggregate cursor and the followers vote on cursor speed by holding down their mouse button. In top-down, users independently control their cursors, but the leader decides whether or not to let the members of her group move by holding down her button.

No Differentiated Roles

Drag-and-drop: Anybody can drag any object. If an object requires more than one user to move [5], its motion is a summed proportion of each selecting cursor's movement.

Rubber Band: Drag-and-drop plus an object-specific colored line extending to each cursor moving it. Object motion is the average of the dragging cursor locations.

Indirect Manipulation: Designed to reduce visual clutter, users indicate which object they would like to move and then press one of four cardinal direction buttons at each edge of the screen to move the object a small amount. Objects and cursors are color-coded.

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Phasing: A timer splits activity into a cyclical 3-step process: 1) each person selects an object to move or group to join, 2) free-range activity on the object or group, and 3) freezing all activity and hiding cursors (for coordination).

STUDY AND RESULTS

We conducted six pilot user studies that consisted of 10-20 participants using a mix of the aforementioned interaction techniques to assemble virtual puzzles and concept maps, common classroom tasks with simple rules. After each study, we iterated on our designs based on feedback and observations. We videotaped each task.

Table 1 shows the delineations between the various types of coordinative actions (virtual actions, verbal utterances) we observed. We found that both epistemic and pragmatic actions [4] could apply to the task or to the user interface. This distinction is useful to researchers of coordinative systems in order to help classify coordinative actions. Epistemic coordinating actions are those done to inform pragmatic actions.

	Epistemic	Pragmatic
Task	Collaboratively placing a concept to test a hypothesis.	Agreeing to place a concept in its intended final location.
Task UI	Asking who else is moving an object to discuss task.	Collaboratively moving an object to a new location.

Table 1: Forms of coordinating actions.

Design factors affecting coordination

We categorized our observations into five factors that affect an interface's support of coordination.

System clarity: The ability of the interface to communicate how to accomplish a goal. Low system clarity resulted in "Where is my mouse?" or "We're supposed to move them?"

State visibility: The more 'state' embedded into the display, the more coordination can be off-loaded from verbal communication, freeing that channel for high-level coordination. E.g. with high state visibility, participants waggled their mouse to recruit others while saying nothing.

Explicit process: Without an explicit process, users would coordinate in a just-in-time manner, fitting in coordinative actions if possible. During the 3rd phase of our *phasing* method, we saw coordinative actions around the task.

Roles: We found defined roles to be a catalyst of negotiation but that roles may also emerge naturally. Role mobility allows participants to adopt and discard roles as appropriate and helps users from getting 'stuck' in non-coordinated behavior.

Agency: Can users see how they might affect the activity and how their participation is attributed? This can affect motivation. E.g. in the bottom-up design, some people did

not know who was controlling their group's cursor so they held down their mouse button and were social disengaged.

Attention Model of Coordination

We created a model that depicts the levels of a user's attention on coordination, increasing in scope. Users can shift their attention between layers as they wish, but will often move from the inside outwards. "Peers," in this model, can refer to a user's sub-group or the entire group of participants. This model can help to evaluate the coordinative affordances of interfaces. For example, the *Rubber Band* method makes peers' goals salient (Fig 1a).

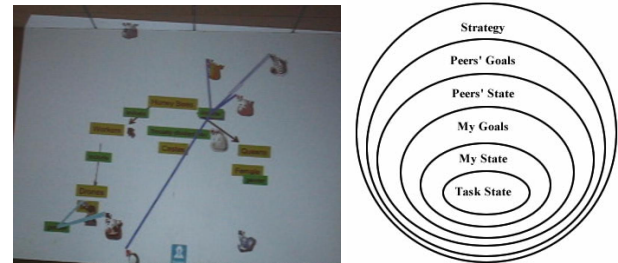


Figure 1a and b: a) The *Rubber Band* interaction method and b) Model of an individual's scope of attention to coordinative levels.

CONCLUSION AND NEXT STEPS

In conclusion, we have explored how interaction methods affect coordination in large groups where each user has a discrete input. We presented six design methods to support coordination that informed a list of five factors that affect an interface's ability to afford coordination. We presented an attention model of coordinative levels. These results may prove useful to researchers of large-scale multi-user interfaces. We plan to create more interaction methods in order to better understand these design factors and create a framework for understanding and creating new ones.

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