Adaptive Rooms, Virtual Collaboration and Cognitive Workflow

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Abstract. This paper introduces the concept of Adaptive Rooms, which are virtual environments able to dynamically adapt to users' needs, including 'physical' and cognitive workflow requirements, number of users, differing cognitive abilities and skills. Adaptive rooms are collections of virtual objects, many of them self-transforming objects, housed in an architecturally active room with information spaces and tools. An ontology of objects used in adaptive rooms is presented. Virtual entities are classified as passive, reactive, active, and information entities, and their sub-categories. Only active objects can be self-transforming. Adaptive Rooms are meant to combine the insights of ubiquitous computing -- that computerization should be everywhere, transparently incorporated -- with the insights of augmented reality -- that everyday objects can be digitally enhanced to carry more information about their use. To display the special potential of adaptive rooms, concrete examples are given to show how the demands of cognitive workflow can be reduced.

Keywords. cooperative buildings, collaboration, cognitive workflow, cognitive ethnography, ontology, virtual collaboration, virtual environments, virtual objects

1 Introduction

The goal in designing virtual collaborative environments is to allow individuals to do everything they can do in real shared spaces and more. As in real spaces people must be able to talk to one another, move around, make diagrams, build models, highlight points of interest for others to consider, and jointly edit documents or 3-D models. The ultimate promise of virtual reality, though, is that users will be able to do things they cannot do in real life: they will be able to conduct new kinds of scientific, business and social explorations via meetings held in "outer space," within a "molecule," inside the "combustion chamber" of an automobile engine, suspended in the "atmosphere" above planet Earth, or in Ms. Frizzle's Magic School Bus. In such cases, users will be able to jointly interact with simulations. One particular aspect of this interaction we are exploring and will report here is how to design virtual environ-

ments to dynamically adapt to the workflow needs of participants – both `physical' workflow and cognitive workflow. How should we embed simulations, information spaces, and other computational tools into virtual environments to facilitate collaborative activities?

Workflow adaptation is a thorny problem. At the most familiar level, collaborative workflow is understood in a pragmatic or `physical' manner as the activities and sub-activities – the tasks and sub-tasks -- which collaborating partners perform. Any typical job, such as assembling an electric motor, can be decomposed into a lattice of component activities. Parts must be collected, compared and sorted, then aligned correctly and fastened. Because some of these activities must be performed before others there is a partial temporal ordering on the task decomposition, hence the use of a decomposition lattice. In ordinary physical environments, collaboration makes this lattice more complicated because we must also decide who will do what; but the temporal structure of the job remains essentially the same. In this context, it is clear what an adaptive room should do: It should adapt the space, furniture and resources available, to the special needs of each sub task. If the task of comparing the parts requires lighting that is brighter than normal, then when that subtask is being performed the lighting should automatically be brighter. If the task of sorting parts requires special bins in which to group parts, then for the sorting phase new bins should appear as needed. Similarly, if alignment is facilitated by a jig, then a jig should be present to hold or re-orient the main motor. The list of useful adaptations can be extended. If several people wish to help in the assembly, and they have not decided to work separately in assembly line fashion, then the physical space around the main assembly platform should expand to comfortably accommodate more people.

This last adaptation – morphing of walls and furniture -- is one we expect to arise in most collaborative tasks in adaptive rooms. Unlike ordinary physical environments where limited space and chairs around a table or computer screen invariably means that some people must stand, in virtual rooms, any number of avatars can be seated because we can expand or deform the table to accommodate convenient placement of chairs. The computer screen, the whiteboard and bookshelves, the corkboard and the stick'ems, can all adapt. Any facet of the environment that is not currently useful may be temporarily removed. Any facet of the environment that might be useful may be temporarily added. To take another example, if I have been using my office to write an essay on adaptive rooms, and my collaborators on a different topic arrive, it is likely that my messy desk will be an inconvenience to us all. Since I wish to keep the state contained in the arrangement of papers on the table, but I also wish to have the workplace optimally configured for my current collaborative activity, I will either create a new room for this new collaboration, or adapt my office. Because the proliferation of virtual rooms for each collaboration and each activity would soon become disorienting and awkward, a better solution to this problem is to have my books and papers contract to a 3D icon, my bookshelves recede, and the whiteboard expand, all to return automatically when my visitors leave. If social needs require it, extra chairs may be whisked into the room, and any writing pads, markers and related office supplies can be provided as needed.

Adaptation to workflow conceived of as physical task decomposition is a problem designers deal with daily. It may seem, therefore, that although going virtual adds options to the design space, it adds nothing, in principle, to the design problem itself.