Planlet: Supporting Plan-Aware Ubiquitous Computing Applications

Gary Look & Howard Shrobe

Artificial Intelligence Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

http://www.ai.mit.edu

The Problem: Ubiquitous computing applications are designed to help people accomplish their tasks by seamlessly merging the physical environment with a ubiquitous computing infrastructure. To make a ubicomp application truly useful, the application needs to have some representation of what task a user is trying to perform and the plan he intends to carry out to accomplish that task. The goal of the Planlet project is to create such a representation for use by ubicomp applications. These applications can then provide appropriate assistance to a user based on his intended plan of action and how much of that plan he has carried out.

Motivation: A ubiquitous computing application may have many types of sensors and actuators which it can use to interact with its users. However, for the application to be able to use these sensors and actuators in a way that would help a user, the application needs to have a representation of what the user is doing. By being "plan-aware", an application can proactively assist a user. For example, by knowing what the user plans to do, the application could reserve necessary resources and configure devices the user may soon need. If certain resources are not available, the application can suggest an alternate course of action. A plan-aware application could also guide users through the steps of a task they are unfamiliar with.

Previous Work: There are many research projects focused on making applications more helpful to their users. This work is different in that we combine a representation of user plans with ubicomp applications that are intended to be available to a user as he works on a task across time and space.

Collagen [4] applies collaborative discourse theory to improve human-computer interaction. Applications written with Collagen use a software agent to collaborate with a user as he works on his task. The agent maintains a model of what the user is trying to do by having a dialog with the user (this dialog includes recording user activities and asking for clarification when necessary). As the user completes parts of his task (and the dialog between user and agent continues) the agent works with the user to perform certain actions when this interaction would be useful. The resulting interaction is similar to two people working together in front of a whiteboard to solve a problem. Our work is similar to Collagen in that we also have a representation of a user's task, but we apply this representation to ubicomp applications whereas Collagen has focused on desktop applications.

ReBa [3] is a system designed to control how MIT's Intelligent Room reacts to user activities in different circumstances. Reactions to particular actions are defined in a behavior. Behaviors can be layered over one another with the behavior on top overriding the lower behavior when two or more behaviors conflict. Our approach is different in that with a model of what the user is trying to do, we can create applications that proactively assist the user as opposed to waiting for the user to do something before the application can react to it.

Approach: In designing Planlet, we identified three stages involving the use of plans that we needed to support in order to make a ubicomp application plan-aware. These stages are plan definition, plan instantiation, and plan execution.

In the plan definition stage, an application uses Planlet to identify the subplans that need to be performed and lays out the producer-consumer relationships between these subplans. A partial-ordering of the subplans is thus determined in this stage. Planlet can be used to define plans with hierarchy, conditional execution, and iteration. At definition time, plans may be defined with properties such as resource assignments and deadlines; these properties are fixed at instantiation time. Plan instantiation may be interleaved with the third stage, plan execution.

During plan execution, Planlet uses its knowledge of the user's plan to inform a ubicomp application of the things a user could be expected to do next. The application uses this information to interact with the user in an

appropriate way, for example, to reserve resources the user may soon use. As the user completes parts of his plan, Planlet updates the application on what other things the user could do. This interaction between Planlet and a plan-aware ubiquitous computing application is illustrated in Figure 1.

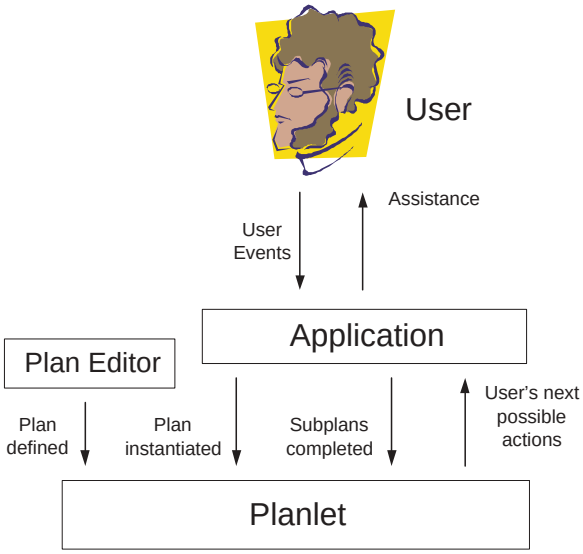

Figure 1: Some form of plan editor (which could be the application, an AI planner, or a plan recognition algorithm) first defines user plans. The application then instantiates a plan, fixing such plan properties as resource assignments. Then, as the user executes his plan, Planlet informs the application of what the user could do next so that the application can take appropriate action.

Impact: Planlet makes it easier for applications to clarify user confusion and proactively meet user needs because it provides a way to represent user plans and manages progress in these plans. The end result are things like smart spaces that are smarter in the way they interact with people, rather than those that require people to work harder in the way they interact with the space.

Future Work: Planlet is being used to create a day planner application that would help its user with his appointments. One scenario envisioned for this application is this: if the day planner knew that the user had a presentation to give at a certain time and place, the planner would make the presentation slides available in the correct room at the right time, without explicit request from the user. The benefit to the user is that he would not need to worry about carrying a laptop with him or if his slides are in a publicly viewable place; the user just shows up and his presentation is ready to go. Planlet is also being used in CMU's Aura Project [2] and the University of Washington's Labscape [1] project.

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