9th International Symposium on
Artificial Intelligence, Robotics and Automation for Space
(i-SAIRAS 2008)

Active and Passive Constraint Enforcement for Activity Planning

Author (PI or lead): Paul Morris
Affiliation: NASA Ames Research Center
Address: MS 269-1 Moffett Field CA 94035
Email:Paul.H.Morris@nasa.gov Phone: (650) 604-4713
Presentation Preference (oral or poster): oral

Extended Abstract (1 page maximum)

Activity planning is an important component of ground operations for actual and simulated space missions. The MAPGEN tool in the Mars Exploration Rover mission introduced a mixed-initiative semi-automated approach for such planning. This has been continued with the ENSEMBLE system, which has been adapted for several space-related applications. These different applications have focused attention on the need to model a diverse variety of constraint types, such as complex mutual exclusions and blackout periods for certain types of activities following other types of activities. The mixed-initiative framework requires both active and passive enforcement of these constraints, where passive enforcement involves alerts the user about violations, whereas active enforcement may revise the plan to remove violations, and maintain a violation-free state when responding to user modifications. In this paper, we discuss the underlying constraint engine and the techniques that are used to model the constraints.

The constraint modeling in ENSEMBLE is based on an underlying planning and scheduling engine called Europa. This provides several core capabilities, including representation of activities with extended durations that may use single or multi-capacity resources and satisfy temporal constraints including precedence orderings, quantitative separation bounds and heterogeneous no-overlap restrictions. It also supports creation and completion of flexible-time plans and calculation of resource profiles for such plans.

We show how the core capabilities can be used to express the different kinds of constraints that occur in applications and enforce them both actively and passively. In particular we describe a strategy for passive enforcement that encodes the different types of constraints as various kinds of resource transactions; these allow efficient detection of violations as oversubscription flaws. A separate strategy is used for active enforcement by placing sub-goals on timelines. Complex overlap restrictions can be captured by different schemes for merging of sub-goals. The active and passive strategies differ from those of MAPGEN in ways that further enhance the mixed-initiative framework.

These approaches have been evaluated and base-lined for several upcoming missions, including Mars Science Laboratory, Phoenix, and a bed-rest study. Testing in ORTs is currently ongoing. Each application leads to further enhancements as new features are added and new types of constraints are encountered.