

Commentary On: In-Space Crew-Collaborative Task Scheduling

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Based on the authors' experience with scheduling for the International Space Station crew, this paper identifies scheduling challenges of a remote manned space mission, describes technology advances required, and suggests a concept of operations. This commentary will mention additional challenges based on my experience with scheduling for the Deep Space Network¹

The Deep Space Network (DSN) is a collection of ground antennas that provide tracking and data services to a wide range of space missions. The complexity of the scheduling problem is mainly driven by the features of a request language, in which missions can more easily specify goals and preferences (Clement & Johnston 2005). We are developing a scheduling engine to be integrated into a mixed-initiative scheduling system being developed in parallel. The design of that system (Clement & Johnston 2006) has given us insight into some of the challenges of mixed initiative scheduling that I believe also apply to manned space missions.

In the Automatic Scheduling section, the authors state, "Automatic scheduling will be the primary mode of developing the task timelines." While this is ideal, users (of the DSN, at least) want to move activities around themselves. This capability is necessary because sometimes hand generating a schedule is easier than specifying the goals. Our goal is to have users manipulate their requests at a high level while a scheduling engine specifies the details, but the user must have control at both levels. The problem with this freedom is that it is easy for users to make changes that make their requests inconsistent with the schedule. So, how can a user interface handle this problem without annoying the user or sacrificing the benefits of managing requests?

The section on Terminology and Standards discusses how terminology should be standardized. Work in ontologies, such as the development of the Semantic Web, aims to solve problems like this. An ontology can be used to standardize semantics as well as translate languages/terminology for particular domains or environments. Thus, it is possible that no group needs to learn any new terminology, but their soft-

ware and reports can automatically use their own terminology as translated from the terminology of the group providing the data.

The appendix discusses challenges of implementing a delay tolerant network (DTN). Currently, relays from Mars rovers through Mars orbiters are pre-planned. As robotic hardware becomes more autonomous, much of this communication will be routed on-the-fly as with the Internet. Spacecraft operations have (and may always be) controlled by specific individuals working for the mission. If a rover wants to relay through an orbiter, the orbiter ultimately decides whether it will happen based on the safety or criticality of its operations. Thus, autonomous spacecraft will evolve to negotiate communications on-the-fly, and since they will likely generate their own schedule of operations, the spacecraft will negotiate events over some future time horizon. In order for a DTN to safely and efficiently communicate data, distributed scheduling technology is needed specifically for networking (Clement & Schaffer 2004).

This kind of negotiation is unique in that delays are long, the spacecraft are usually only able to communicate periodically (because of orbital occlusions), and the spacecraft can know in advance when this will occur. For a specific negotiation protocol, a spacecraft can determine by when the negotiation among a group of spacecraft must begin in order for the spacecraft to reach consensus before the relay begins (Clement & Barrett 2003).

References

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