Tracking Collaborative Decision-Making by Capturing Asset Deployment Rationale

Daniel C. Berrios
University of California, Santa Cruz, CA 94035

Trevor Hodges
University of California, Davis, CA 95616

Richard M. Keller
NASA Ames Research Center, Moffett Field, CA 94035

I. Abstract

The development of increasingly sophisticated autonomous vehicles capable of being deployed from great distances and for extended periods of time brings new challenges, including tracing collaboratively made decisions regarding these assets and relating collected data to such decisions and their rationale. For scientific data gathering, this rationale commonly is in the form of research questions, hypotheses, and observations. By "closing the loop" between motivations and rationale for gathering data and the data themselves, their intended uses are made more clear, and a precise, evaluable trace of mission actions is generated. Tracking asset deployment rationale facilitates long-term mission planning and, particularly for complex data gathering missions, can prevent repetitive or extraneous deployments and reduce the likelihood of overlooking deployment opportunities.

We have had two opportunities to develop ontological models for describing data gathering rationale and linking them to collected data stored in the ScienceOrganizer semantic information repository.[1] The models include

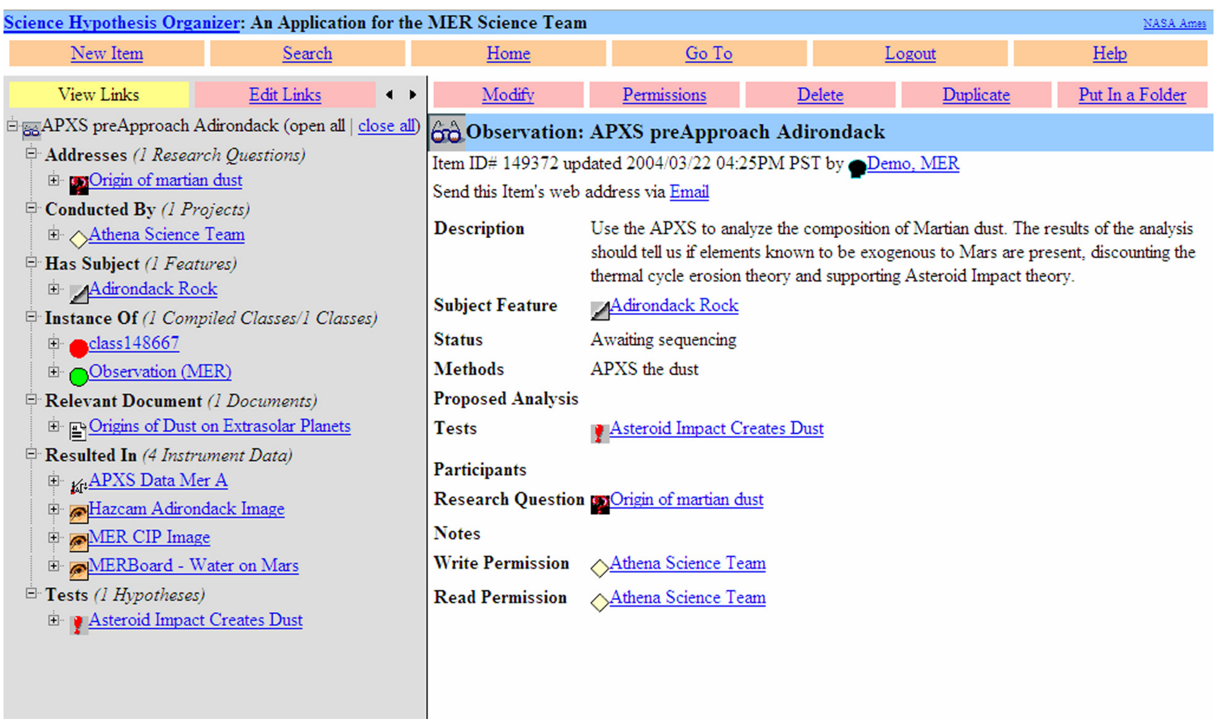

Figure 1. Model for collaborative decision making during the MER missions. An example of an *observation* is shown on the right. Listed on the left are logically related items, including a *research question* addressed by the *observation*, the geologic *feature* that is the subject of the *observation*, four *instrument data* sets collected as a result of the *observation*, and the *hypothesis* tested by the *observation*.

concepts for describing assets, activities, and various types of scientific rationale, but also, importantly, the logical connections to data products (e.g., instrument data). We have demonstrated use of these models in some form in two settings: the Mars Exploration Rovers (MER) missions and the Adaptive Ocean Sampling Networks Monterey Bay 2006 data collection campaign (MB06).

We first attempted to demonstrate this type of data and rationale tracking using models of MER data. We examined MER work processes that yield requests for *observations* to be made with MER *instruments*. These observations are designed to address *research questions* and test *hypotheses* relating to the formation of Mars and its geological features.. The observations result in various types of *instrument data* that can be used to refute or support the hypotheses.[2] These concepts (in italics above) and logical relationships (underlined above) formed the basis for the rationale-data tracking model. We created exemplars for each concept and linked them together for a demonstration of the information retrieval, navigation, and visualization potential of the model as implemented in ScienceOrganizer (Fig. 1). Note that, with the addition of instrument/asset command concepts, the model could be used to provide so-called round-trip data tracking (tracing data back to the command sequences from which they were generated), but in fact traces even further back to motivations for commands.

In the summer of 2006, we extended our data-rationale tracking model as we prepared to deploy ScienceOrganizer to support MB06. This campaign involved the collaboration of almost a dozen scientific teams to direct a variety of ocean-observing and sampling assets, including vessels, ROVs, and gliders and other underwater autonomous vehicles. This collaboration chose to use a voting method to select which course of action to take with various assets. The team communicated daily via telephone, sharing proposals for asset deployment and holding discussions via a web-based science data web portal (separate from ScienceOrganizer). To support the tracking of these decision-making elements, we enhanced the MER model by adding concepts describing competing proposals to test hypotheses, *votes* on such proposals, as well as email or other documents that discuss these proposals or their rationale (Fig. 2).

The decision-making process for both MER and MB06 have a number of similarities: the generation of research questions and/or specific hypotheses that may be tested by observations; negotiation among multiple parties on proposals for observations through voting or other processes; execution of observations yielding instrument data;

Figure 2. Additional concepts and logical relations added to support the MB06 data campaign. These include *proposal* (an example of which is shown on the right side), *vote* in favor of or against *proposals,* and *email* or other *documents* that may include discussions of a *proposal* (listed at left).

analyses of data that can refute or support hypotheses. This suggests the kinds of decision and data-tracking models we developed for MER and MB06 could be applied to a wide variety of collaborative-control data gathering missions.

References

1. Keller, R. M. et al. *SemanticOrganizer: A customizable semantic repository for distributed NASA project teams* 3rd International Semantic Web Conference (ISWC2004), Hiroshima, Japan, 2004.
2. Wick, J. V., Callas, J. L., Norris, J. S., Powell, M. W. & Vona, M. A., III. *Distributed operations for the Mars Exploration Rover Mission with the science activity planner* Aerospace, 2005 IEEE Conference, 2005.