



NASA SBIR 2009 Phase I Solicitation

01.09 Software for Space Communications Infrastructure Operations

Lead Center: JPL

Participating Center(s): GRC, GSFC

New technology is sought to improve resource optimization and the user interface of planning and scheduling tools for NASA's Space Communications Infrastructure. The software created should have a commercialization approach with the new modules fitting into an existing or in development planning and scheduling tool.

Purpose (based on NASA needs) and the current state of the art:

The current infrastructure for NASA Space Communications provides services for near-Earth spacecraft and deep space planetary missions. The infrastructure assets include the Deep Space Network (DSN), the Ground Network (GN), and the Space Network (SN). Recent planning for the Vision for Space Exploration (VSE) for human exploration to the Moon and beyond as well as maintaining vibrant space and Earth science programs resulted in a new concept of the communications architecture. The future communications architecture will evolve from the present legacy assets and with addition of new assets.

NASA seeks automation technologies that will facilitate scheduling of oversubscribed communications resources to support: (1) Increased numbers of missions and customers; (2) Increased number and complexity of constraints (as required by new antenna types); and (3) decreased operations budgets (both core communications network operations and mission side operations budgets).

Core Capabilities:

Intelligent Assistants

In order to automate the user's provision of requirements and refinement of the schedule, "intelligent assistant" software should manage the user interface. Assistants should streamline access and modification of requirement and schedule information. By modeling the user, this software can adjust the level of autonomy enabling decisions to be made by the user or the automated system. Assistants should try to minimize user involvement without making decisions the user would prefer to make. The assistants should adapt to the user by learning their control preferences. This technology should apply to local/centralized and collaborative scheduling.

In a conflict-aware scheduling system (especially in a collaborative scheduling environment), conflicts are prevalent. With the concept of one big schedule from the beginning of time, real time, to the end of time, resolving conflicts become a difficult task especially since resolving conflicts in a local sense may affect the global schedule. Therefore, an intelligent assistant may provide decision support to the system or the users to assist conflict resolution. This may involve a set of rules combining with certain local/global optimization to generate a list of options for the system or users to choose from.

Resource Optimization

The goal of schedule optimization is to produce allocations that yield the best objectives. These may include maximizing DSN utilization, minimizing loss of desired tracking time, and optimizing project satisfaction. Each project may have their own definition of satisfaction such as maximal science data returned, maximal tracking time, best allocation of the day/week, etc. The difficulty is that we may not satisfy all of these objectives during the optimization process. Obviously, optimal solution for one objective may produce worse results for the other objectives. One possible solution is to map all of these objectives to an overall system goal. This mapping is normally non-linear. Technology needs to be developed for this non-linear mapping for scoring in addition to regular optimization approaches.

Optional Capabilities:

Multiple Agents

In an environment where all system variables can be controlled by a single controller, an optimal solution for the objective function can be achieved by finding the right set of variables. In a collaborative environment with multiple decision makers where each decision maker can only control a subset of the variables, modeling and optimization become a very complex issue. In the proposed collaborative scheduling approach, there are many users/agents that will control their own allocations with interaction with the others. How we model their interactions and define system policy so the interaction can achieve the overall system goal is an important topic. The approach for multiple decision-maker collaboration has been studied in the area of Game Theory. The applications cover many areas including economics and engineering. The major solutions include Pareto, Nash, and Stackelberg. There are many new research areas including incentive control, collaborative control, Ordinal Games, etc. Note that intelligent assistants and multiple agents represent different points on the spectrum of automation. Current operations utilize primarily manual collaborative scheduling, intelligent assistants would enhance users ability to participate in this process and intelligent agents could more automate individual customers scheduling. Ideally, proposed intelligent assistants and distributed agents would also be able to represent customers who do not wish to expose their general preferences and constraints.

A start for reference material on this subtopic may be found at the following:

<http://ai.jpl.nasa.gov> in the publications area;

<http://scp.gsfc.nasa.gov/gn/gnusersguide3.pdf>, NASA Ground Network User's Guide, Chapter 9 Scheduling; and

<http://scp.gsfc.nasa.gov/tdrss/guide.html>, Space Network User's Guide, SpaceOps Conference Proceedings.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 1 Deliverables

Propose demonstration of Intelligent Assistants, Resource Optimization, or Multiple Agents on a number of communication asset allocation problem sets (involving dozens of missions, communications assets, and operational constraints). End Phase deliverable would include a detailed rationale for ROI in usage of said technology to communications asset allocation based on knowledge of current and future operations flows.

Phase 2 Deliverables

Demonstrate Intelligent Assistants, Resource Optimization, or Multiple Agents on actual or surrogate communication asset scheduling datasets. Deliverables would include use cases and some evidence of utility of deployment of developed technology.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.