Commentary on the paper:

Automated Allocation of ESA Ground Station Network Services

Authors: Damiani, Dreihahn, Noll, Nièzette, Calzolari

Eduardo Romero
CONAE - Argentine National Space Agency
Paseo Colón 751, (1063) Buenos Aires
Argentina
eromero@conae.gov.ar

Héctor Esteban Carranza
Dpto. de Electricidad y Electrónica - U.N.R.C.
R 36 Km 601, (5800) Río Cuarto
Argentina
hcarranza@ing.unrc.edu.ar

Overview. The ground stations owned by the European Space Agency (ESA) and other cooperative stations constitute the ESA TRACKing network (ESTRACK) that supports many space missions. This paper describes the design concepts of the ESTRACK Planning System (EPS), the software system that will be used for planning the ESTRACK activities by the EMS (ESTRACK Management System).

The planning is carried out in an iterative refinement process with the interaction between every mission and the EMS. The model used assumes a simplified version of the services a ground station can provide to the missions. For every required service there are only two possible configurations: attending it or not, and no further distinctions are made. The inputs of the EPS are the following:

1. The previous plan;
2. The new ground services each mission requires;
3. The ground services each station can provide;
4. The constraints and priorities to be considered for planning.

The constraints are rules that say whether it is legal or not to make an assignment of a ground resource to a required ground service from a mission. Examples of constrains are: the visibility windows of a satellite by a given ground station; whether a ground station is operative or not; and the minimum time overlap necessary for handovers.

After assigning ground resources to a mission, priorities are used to decide resource conflicts, essentially, what satellite has priority over a given ground station. The EPS follows three execution steps: it refines the current plan; it checks the new plan for inconsistency; and, when some are found, it repairs the plan. Afterwards, the plan generated by EPS is sent to each mission in order to continue with the plan refinement cycle.

Emphasis is made in the second step of the EPS execution: the consistency check of the refined plan. For consistency check the authors classify the constraints in three known classes: binary constraints, linear constraints and disjunctions of binary constraints; and they describe how to check the constrains consistency using various techniques.

Comments. Planning the ground services of several ground stations is an important and difficult problem. An intelligent distribution of the ground services can save a large amount of ground resources. We think the work presented in this paper is a major contribution to solve this problem. The authors grasp the essence of this planning problem in two ways. First, the ground services that the several ground stations can provided to a mission are taught as a whole unique service, allowing optimization. Second, it is fundamental the use of a plan refinement strategy enriched by the user's needs and knowledge.

The following topics could be considered for future enhancements of the system.

The table of priorities are used to take local decisions about ground services assignments, but it is not clear how the quality of a whole plan is affected by these decisions.

One of the comments in the paper for future work concerns how the authors intend to supersede the simplified modeling of ground station configurations commented above. The planned future new version of the system will go beyond the two configurations: attend or not the requested service. It will be able of distinguishing between different configurations offered by the same ground station that satisfy the requested service. For example, by the use of different antennas. This extension would allow: to model several configurations of ground equipment for every mission; to model the sharing of ground equipment by different missions; and to model different levels of redundancy in the attention of a mission. We find this extension important because the redundancy of a configuration is relevant for the reliability of the service. This extension of the system would require a new table defining the priorities of each service similar to that shown in table 2 of the paper, but this time, it would include the priorities for each configuration of each ground station for every mission. This would increase the complexity of the problem. Furthermore, it might be difficult to define this new table. And the table should be able to change dynamically according to mission operation control center's information. For example, if a satellite needs special attention due some contingency, or during early orbit maneuvers, the priorities may vary substantially. This is not a minor problem because conflicts are solved using this table, and so, the optimality of a plan relies on it.