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Tools for Coordinating Planning Between Observatories

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Abstract. With the realization of NASA's era of great observatories, there are now more than three space-based telescopes operating in different wave bands. This situation provides astronomers with a unique opportunity to simultaneously observe with multiple observatories. Yet scheduling multiple observatories simultaneously is highly inefficient when compared to observations using only a single observatory. Thus, programs using multiple observatories are limited not by scientific restrictions, but by operational inefficiencies.

At present, multi-observatory programs are initiated by submitting observing proposals separately to each concerned observatory. To assure that the proposed observations can be scheduled, each observatory's staff has to check that the observations are valid and meet all constraints for their own observatory; in addition, they have to verify that the observations satisfy the constraints of the other observatories. Thus, coordinated observations require painstaking manual collaboration among staffs at each observatory. Due to the lack of automated tools for coordinated observations, this process is time consuming and error-prone, and the outcome of requests is not certain until the very end. To increase multi-observatory operations efficiency, such resource intensive processes need to be re-engineered.

To overcome this critical deficiency, Goddard Space Flight Center's Advanced Architectures and Automation Branch is developing a prototype called the Visual Observation Layout Tool (VOLT). The main objective of VOLT is to provide visual tools to help automate the planning of coordinated observations by multiple astronomical observatories, as well as to increase the probability of scheduling all observations.

1. Introduction

Planning and executing observations that are coordinated across multiple spacecraft is essential to reaching future space and earth science goals. The current lack of automated tools and interfaces across observatories makes coordinated observing resource intensive for the observatories and consequently limits scientific research. The proposed tools will facilitate the coordinated observing

processes necessary to achieve the concept of a "virtual observatory" that will spawn a new era of science data collection.

2. Objectives

A number of advanced visual tools are currently being developed to help the observers and principal investigators of astronomical phenomena in their observation planning. Among early entries in this arena are the Scientist's Expert Assistant[1] and Astronomer's Proposal Tool (APT)[2], which enable the observers to simulate the quality of their observation based upon observing parameters (e.g., target properties, instrument setup, and observatory condition). However, the outcome of the proposed requests is still uncertain as the schedulability of the observation, which is affected by observatory related factors, is still unknown for the requested time period. This problem is magnified many-fold when collaboration among observatories is needed to coordinate the planning of a set of observations through multi-wavelength campaigns that involve variable phenomena, interacting binary systems, and other events of extreme interest to astronomers for the quantitative understanding of galactic and extra-galactic phenomena and for developing realistic physical models.

The main objective of the VOLT project is to provide visual tools to help automate the planning of coordinated observations by multiple astronomical observatories, as well as to increase the scheduling probability of all observations. Thus, these tools will not only provide the users with the required schedulability data, but will also help and guide them in determining the best possible times when the group of observations may be placed in compliance with their coordination goals.

The intended goals of VOLT are:

- The tools will not replicate the software capabilities of the planning and scheduling facility associated with an observatory. Rather, they will interface with these software components, using state-of-the-art communication mechanisms, and retrieve the desired data. Required formatting and normalization of data may be performed by these tools if necessary.
- The coordination of observations will be modeled as a network of temporal constraints that can be solved in a satisfactory manner by use of an appropriate constraint satisfaction engine. Cost-effective solutions will employ free or low-cost search engines.
- If coordinated observations are not schedulable as specified, explanatory help on constraints and constraint relaxation will be provided.
- Emphasis will be on reuse and modularity by making tools easily extensible and configurable to new missions. Following initial application to space-based observatories, later efforts will expand to include queue-based ground observatories, other space sciences missions, and other domains such as earth sciences missions.

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[1] `http://aaaprod.gsfc.nasa.gov/SEA`

[2] `http://www.stsci.edu/apt/`

3. Impact

The primary impact of the tools provided by VOLT will be in the arena of coordinated observations involving two or more observatories, as shown below:

- Coordinated Observations are limited by observatories because of the complexity of the planning process, and the manpower and manual effort required for coordination. VOLT seeks to automate this planning; to enable new types of complex, coordinated observations that are not feasible with current manual methods, and to make coordinated observing a low cost, routine task rather than a special exception.
  Although multi-observatory coordinations involving three to five observatories are envisioned for some studies, currently very few coordinated observations (e.g., 7 - 10% of observations for HST) are requested and take place due to the uncertain, manual and labor-intensive nature of such coordinations. Due to the lack of resources, some observatories (e.g., FUSE) do not support coordinated planning except in extreme cases. Users themselves are also discouraged from requesting three or more coordinated observations due to the complexity involved. These new tools will help both astronomers and observatory scheduling staffs in planning for such complex observations. They will reduce the manual workload, and thus the cost, of coordinated and time-constrained observations.
- Observers with coordinated programs have few tools to will assist them in planning their observations effectively. VOLT will fill this void by applying new technology and innovative solutions for this increasingly important aspect of science planning, not only by automating the procedure, but also by providing visual cues on coordination, and by allowing users to look for alternate solutions. By helping in the planning of observations, these tools can also help in generating more feasible requests even for a single observatory. The pluggable nature of these tools (into other proposal/observation planning tool sets such as APT) will provide an integrated environment enhancing the observation's scheduling probability. The net result will be an increase in science data that would help in the understanding of galactic and extra-galactic phenomena, and benefit a wide variety of astronomical research.

Once VOLT has achieved the above two goals, more astronomers will apply for coordinated observations. Coordinated observations will have become feasible enough that observatories can take a further step in coordination: accepting a single proposal that will apply to all observatories involved in the coordinated program, thereby permitting a given scientific topic to be investigated as a whole, rather than as fragmented proposals that the observer hopes will succeed at each of the separate observatories requested.

4. Acknowledgments

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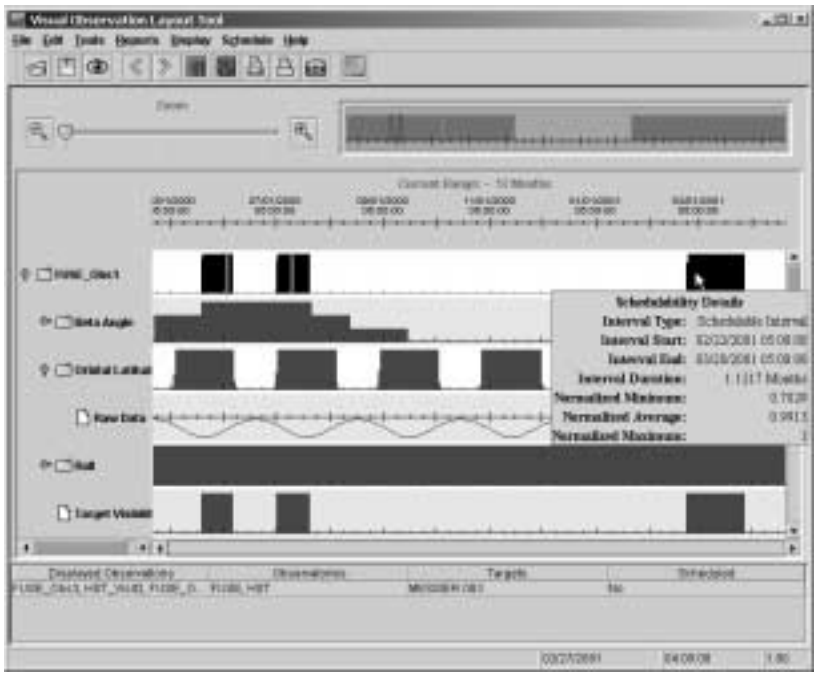

Figure 1. The VOLT prototype schedulability display

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