Long and Short Term Scheduling Tools in ESO

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Abstract.
Given the cost of the constructing and operating telescopes, particularly 8-meter class telescopes like the Very Large Telescope (VLT), it is desirable to maximize the efficiency of telescope operations and therefore scientific productivity using scheduling tools. We have developed two software tools based on the STScI SPIKE engine (Johnston & Miller 1994), which was originally written for the use of the Hubble Space Telescope. This software was adapted to support the constraints of a ground based telescope. The Long Term Scheduler (LTS) is a software tool used twice a year to schedule all the observing programmes accepted for a six month time period. It is a Decision Support System that helps the user best juggle the astronomical constraints of each observing proposal, like target visibility, required moon phase, links among different proposals and critical times. A LTS prototype was used for ESO Period 64 to schedule two out of seven ESO telescopes. The Short Term Scheduler (STS) can be used to schedule service observing observations at the VLT on a nightly basis. The STS can also be used to react quickly to changing weather conditions. After discussing the tools, early operations experiences are presented.

1. Introduction

The Long and Short Term Scheduling Tools (respectively, LTS and STS) are part of the ESO Observation Handling Subsystem (OHS), a collection of tools for processing and managing observing proposals, observing schedules, and observation sequences in the form of Observation Blocks (OBs) (Chavan et al. 1998). The LTS is used twice a year to analyse the characteristics of an accepted set of observing proposals and to produce a six month ("period") schedule. On the other hand, the STS is used nightly to produce OB execution sequences (timelines) that minimze operations overheads against a user selectable set of weather conditions, instrument configurations, and scientific priority.

2. Long Term Scheduler

2.1. Inputs

Scheduling the programmes for all ESO telescopes is difficult. The LTS has to take into account telescope availability limitations, Principal Investigator (PI) defined observation scheduling constraints, and scientific priority assigned by peer-review. The telescope availability limitations include technical time periods that have to be reserved at regular intervals, instrument availability and instrument change overhead. There are several PI defined scheduling constraints, all of which can be entered on the revised ESO proposal form first introduced in late 1998. Users define a set of targets to be observed – this target set is used to construct a **Target Visibility** function. For each target, a Piecewise Continuous Function (PCF) histogram is constructed with highest value during the nights when the target is best visible and value 0 when it is not visible at all. The target visibility function for the whole programme is the merger of the individual target PCFs. Required **Moon Phase** is also specified – the user can choose among three values: dark, gray, no restriction. **Links between different observing runs** are also allowed. Very often a programme must be split into two or more separate but linked observing runs with a fixed temporal intervals. Such links (or chains) can also be defined between observing runs of different programmes (e.g. on different telescopes). **Time Intervals to avoid** (i.e. periods during which observations should not be scheduled) can optionally be specified by PIs. The PI can require that the programme has to be allocated only during a specific **Night Fraction**, i.e. during first or second half of the night. Finally, users can specify **Preferred Month(s)**. Usually such preferred months should overlap the best target visibility period, but some times they do not. Scientific priority is always given highest weight.

2.2. Functionalities

The LTS is used to analyze the accepted programmes and to create the six month schedule for all ESO telescopes. To analyze the submitted programmes, a programme browser was implemented. The LTS user can select and sort the programmes with a number of criteria, such as telescope, instrument(s), service/visitor programmes, programme rank, requested moon phase, and requested seeing. Tabular and graphical reports can be generated for the selected programmes. Example reports include RA distribution vs requested Moon phase, targets distribution, instrument distribution, requested seeing or operations mode (Service or Visitor).

Since it is impossible to satisfy all constraints and links for all programmes when constructing the schedule, the LTS user can relax certain constraints for any given programme, i.e the PI defined constraints and the amount of time allocated.

Once a complete set of programmes (and possibly sub-programmes) have been selected and their constraints modified, the actual schedule is constructed using a GUI. This timeline GUI displays a six month time range showing the sequence of scheduled programmes. Selecting a programme displays its constraints over the six month period, i.e. all the useful information is displayed simultaneously. Although the LTS can schedule programmes automatically, user specified programmes (e.g. technical time) can also be scheduled manually at fixed times, and then the automatic scheduling algorithms can be run to complete the schedule. Since it is rare that the automatic scheduling algorithm produces a completely acceptable schedule, the LTS user is also allowed to change the schedule by dragging and dropping programmes along the timeline widget.

3. Short Term Scheduler

The STS is used during science operations to support service observing. Before a six month observing period begins, PIs with approved Service Mode programmes must submit a detailed description of their observation programme in the form of Observation Blocks (OBs). An OB is considered to be the smallest schedulable unit. In preparation for a service observing run (typically two weeks long), the set of all schedulable OBs are selected by the ESO operations staff and the STS is used to construct a series of reports about instrument configuration, scheduling constraints, and target visibility. This pre-selected set of OBs and its associated report set is collectively known as the Medium-Term Schedule (MTS). During the actual service observing run, the STS is used nightly to construct OB execution sequences (timelines), using the MTS as input. These timelines attempt to minimize operations slack-time vs expected (or actual) observing conditions and available instrument configurations.

3.1. Problem Definition

Although similar, the STS problem is more difficult than the LTS problem because of the more detailed scheduling constraints. Target visibility takes into account not only the target RA, but also declination. The moon constraints include not only moon phase, but also the moon rise/set times and the moon-target distance. Weather constraints include sky transparency and seeing. Two kinds of timing constraints are allowed: links (chains) of OBs and Absolute Time Intervals during which an OB must be executed. Obviously, scheduling objectives can be both complex and contradictory. Although the main goal is to maximize the telescope utilization, it is also a high priority to schedule OBs with high scientific priority even if that would decrease telescope efficiency in an absolute sense. Similarly, minimizing the instrument setup time implies grouping and executing OB sequences with the same instrument configuration, but that often means that some OBs will not be executed at their optimal airmass. Having these multiple objectives means that we need multiple algorithms with different weights for different objectives. For example, some algorithms cover the ranking and the airmass, rather then the instrument setup. These algorithms could be used if all OBs have similar instrument configuration. Conversely, if all OBs have the same scientific priority, it makes no sense use algorithms that give great importance to scientific priority (Chavan et al. 1998).

3.2. Functionalities

The most important STS component is a timeline GUI that uses Universal Time and Local Siderial Time as its timescales. This widget shows the OB execution sequence of the currently selected schedule. When an OB is selected, its constraints are displayed along the time scale. As in the LTS the user can pre-assign some OBs at certain times and lock them. The scheduling algorithms can be run to complete the timeline. Drag-and-drop functionality allows the user to move OBs to revise the automatically generated schedule. The final timeline can than be accepted and stored for later execution, or sent to the telescope for immediate execution. If weather conditions change or some unexpected event happens during the night, the STS user can easily change the scheduling parameters (like sky transparency and seeing) and reschedule the rest of the night with the not yet executed OBs.

4. Early Operations Experiences

The LTS was used to schedule two telescopes out of seven during the current ESO semester. As expected, experience shows that it is never possible to satisfy completely all *a priori* constraints. The scheduling process is an iterative process: (1) identify constraints that cannot be respected; (2) edit the programme constraints; and (3) run the scheduling algorithm. If it is still impossible to complete the schedule, then iterate this process until a satisfactory schedule is produced. For the current semester, two days were needed to schedule two telescopes. At that time, the released LTS did not yet display and manage links and timing constraints. Most of the time was spent analysing the proposals and revising these input constraints. Having all programme constraints displayed in the tool and editable would save a lot of time. The next release, scheduled for December 1999, will display all constraints. The ESO scheduling expert, who has been doing this job for almost 20 years, needs about two weeks to schedule seven telescopes. Our hope is that the LTS will allow even an astronomer with relatively little scheduling experience to complete the entire ESO period schedule for 7 – 9 telescopes in one week.

Our STS experience has been more limited. The VLT science operations staff is using the STS as a support tool, but not yet to schedule OBs on a regular basis. STS reports and the programme constraints plots are used to organize OB information and decide which OBs to execute, but OB execution sequences are constructed manually outside of the STS. Two chief lessons have been learned: we need to deliver a good STS user manual, because of complexity of the problem/tool; and that the transition from manual scheduling to semi-automatic scheduling with a tool like the STS is slow and often implies also an organizational change which is not easy to adopt. Therefore we are going to deliver a complete STS release at VLT-UT1 and VLT-UT2 with a complete and detailed user manual and we are planning to assist the Paranal users more closely, directly at the telescope as time and resources permit.

References

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