GlSch: Observation Scheduler for the GLORIA Telescope Network

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ABSTRACT

This paper proposes the design and development of a scheduler for the GLORIA telescope network. This network, which main objective is to make astronomy closer to citizens in general, is formed by 18 telescopes spread over four continents and both hemispheres. Part of the management of this network is made by the network scheduler. It receives the observation requests made by the GLORIA users and then sends it to the most suitable telescope. A key module of the network scheduler is the telescope decision algorithm that makes possible to choose the best telescope, and thus avoiding offering an observation to a telescope that cannot execute it. This paper shows two different telescope decision algorithms: the first one is only based on weather forecast, meanwhile the second one uses fuzzy logic and information from each network telescope. Both algorithms were deployed in the GLORIA network. The achieved results coupled with a comparative of their performance is shown. Moreover, the network scheduler architecture, based on a hybrid distributed-centralized schema, is detailed.

Keywords: Astronomy, telescope network, scheduler algorithm, fuzzy logic, software

1. INTRODUCTION

Over the last decades, there has been an increase in telescope network implementations. There is a huge interest in making astronomy closer to students and citizens in general [1,2]; providing easy-to-use web tools to awake their interest. On the other hand, telescope networks focused on professional astronomers have also been developed [3,4].

Main part of these networks is based on a coordinator or scheduler that manages all the requests. These requests will include information about the target to observe and also how to observe it, i.e. the constraints. Depending on this data, the scheduler will propose the observation to a specific telescope and afterwards, it will execute the observation itself. The design and implementation of the scheduler in the network can be distributed or fully centralized. The distributed architecture [5] usually includes a central node that decide the telescope and local nodes that schedule all the received observations. On the other hand, centralized systems [6] schedule all the telescope observations in the central node. The telescope only acts as a sequencer, receiving instructions and generating data.

In the last term of 2014, the GLORIA network [1] was launched with the aim of create a world-wide telescope network where users could research in astronomy using robotic telescopes, and/or analyzing data which other users have acquired. It integrates telescopes that have been working in various scientific fields and dissemination issues, creating a heterogeneous telescope network. As a part of this network, a scheduler has been designed and it is being implemented and deployed. This scheduler manages all the observation requests and decide the telescope that will be offered the observation. This decision is made through a telescope decision algorithm.

This paper details the GLORIA network in section 2, as well as the architecture of the scheduler in section 3. The different telescope decision algorithms are explained in section 4. Next, the statistic results over the network usage are shown in section 5. Finally, conclusions are in section 6.

2. THE GLORIA TELESCOPE NETWORK

The GLORIA network integrates 18 telescopes worldwide (Figure 1) that had been working in various scientific fields and dissemination issues, creating a heterogeneous network where telescopes time is shared between owners and the GLORIA network.

Figure 1. Geographic location of the GLORIA telescopes.

The underlying idea in GLORIA is that the more eyes we would put on the sky the more and greater the scientific discoveries that will be achieved. Taking advantage of collective intelligence [7] the huge amount of astronomical data can be analyzed by both professional and amateur astronomers. Thus, in order to try to improve the way of doing astronomy research, users will be guided through the different tasks the research requires. Each kind of research has been called experiment. There are two kinds of experiments: those that require a telescope, which have been called *on-line experiments* and *off-line experiments* which work on data produced by the GLORIA network. The available off-line experiments are: *Personal Space*, where you choose an important event in your life and see the sky that was directly overhead at that exact moment; or *Solar Activity*, where you can contribute to the measurement of solar activity; and *Variable Stars* that allows the analysis of the light curves of the stars.

On the other side, on-line experiments are also divided into two categories: teleoperation and batch. The first one is used to directly control the telescope at a specific date and time, which is chosen by the user. At that date, user will be able to control the telescope mount to point at a specific target, select the filter, focus and set the exposure time to take an image that can be finally downloaded. On the other hand, in batch mode, users do not control the telescope; instead, a request to observe a target is submitted to the network and the scheduler will manage the observations.

3. GLSCH: OBSERVATION SCHEDULER

Most of the telescope networks that are currently in use or that are being developed have a common characteristic: their telescopes are only used by the network and they have the same control system. However, one of the key factors of the GLORIA network is that the telescope usage in the network is shared with the telescope owner; the idea is to offer, at least, the telescope idle time to the GLORIA community. This private and public coexistence make mandatory the use of the telescope own control system and the local scheduler provided with it. This fact makes the GLORIA network to be heterogeneous not only because its telescopes have different features, but also because there are different control systems to manage them (RTS2 [8], ACP [9] ...). Moreover, to combine the existence of a network scheduler to manage the entire user requests, and also keep the telescope autonomy, the telescope local scheduler has to belong to the GLORIA scheduler architecture.

The GLORIA scheduler manages all the user requests, taking into account the constraints to be satisfied and deciding to which telescope the observation will be offered. Then, the own telescope scheduler will include the observation within the night plan which has to be executed. The figure 2 shows the scheduler hybrid distributed-centralised architecture. It is based on 3 layers: the upper one formed by a unique node the Central Node. The

middle layer where there is a Local Node for each telescope in the network and finally the lower layer where the telescopes themselves are located.
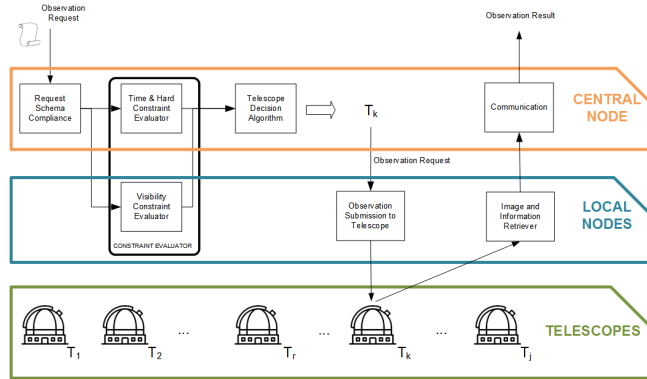

Figure 2.   GlSch architecture.

3.1 Observation management process

The first step of the observation management process is made by the Central Node, once the user has submitted the observation it has to assure that the request is compliant with the request schema. Then a constraint analysis is made. The constraints are divided into time constraints, hard constraints and visibility constraints. The analysis of the first two ones is made by the Central Node. Time constraints define a time window where the observation has to be performed. If this window is within the margins the scheduler is processing, the request analysis will continue; if not, it will be schedule later. Next constraints to be checked are the hard ones; these are constant or can be considered as constant from the point of view of the telescope/observatory. The visibility constraints depend on the exact time the target will be observed, e.g. target altitude. The Central Node will communicate with the local nodes to provide them all the information needed to make a visibility study and decide if the target can be observed or not. Finally, the Central Node, through the decision algorithm, will choose the telescope that will be offered the observation.

The Local Node, associated to the chosen telescope, notifies the observation to the telescope local scheduler. The ways of submitting a new observation to the third-party schedulers includes from creating and uploading a new file (ACP) to use an specific interface to create and then scheduler a target (RTS2, some custom systems). Then the telescope scheduler manages the observation including it into its night plan. The result of this process can be positive when the observation images have been taken; or negative, when the observation has not been executed. If local telescope scheduler completes the observation, the local node fetches the images and a notification is sent to the central node which updates the request state. On the other hand, when no images have been taken, a reallocation process, to choose another telescope, is started.

4. TELESCOPE DECISION ALGORITHM

The difference in the architecture and usage of the network makes the scheduler main goal to be also different. While minimizing the time per observation is the main objective in most of the telescope network, the principal GLORIA objective is to maximize the number of completed observations. As each GLORIA telescope has its own control system with its own local scheduler, the observation time cannot be controlled. Each GLORIA request will be included in the telescope night plan and GLORIA does not have any control about the execution time slot. To avoid offering an observation to a telescope that cannot execute it and then making the overall process longer, the telescope decision algorithm is crucial.

Next, the two telescope decision algorithm that has been designed and implemented are explained.
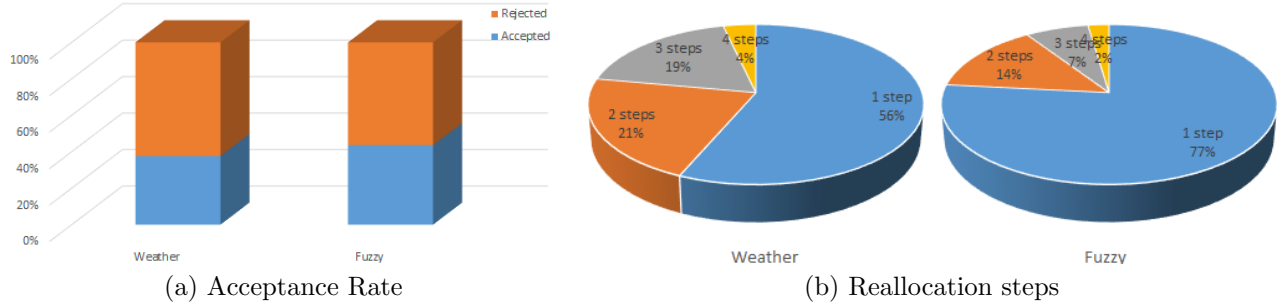
(a) Acceptance Rate   (b) Reallocation steps

Figure 3. Algorithm performance comparative

4.1 Weather forecast algorithm

This telescope decision algorithm is based on weather forecast. This information has been taken from *7timer* [10], a free project that provides specific information for astronomy. The telescope decision algorithm receives the weather forecast for every telescope that passed the constraints. For each of them, a score is computed taking into account the weather condition in its night hours, the parameters considered are the weather forecast (cloud cover and precipitation type) and the seeing.

4.2 Fuzzy logic algorithm

This telescope decision algorithm uses a fuzzy logic model to score each available telescope. The fuzzy model uses different kind of input parameters: astronomical weather information, target quality observation and telescope network feedback.

The astronomical weather parameters informs about the weather condition at the observatory location: weather forecast and seeing as they were used in the weather forecast algorithm. The parameter used to measure the target quality at the observatory location is the Target Transit Altitude. Finally, there are two telescope network feedback parameters to include information about the previous performance of the telescopes. The User Score, once an observation is completed, GLORIA users score the image taken by the telescope. And the Telescope Acceptance Rate, the percentage of executed observations over the total offered ones.

5. RESULTS

The scheduler that has been described coupled with the detailed decision algorithms were deployed and tested into the GLORIA network. The experiment consisted of analyzing the information produced by the network during two periods. In the first one, the weather forecast algorithm was used, meanwhile in the second period the fuzzy logic one was active.

Figure 3a reveals that the acceptance rate for both type of algorithm are quite similar: 37,96% when the weather forecast algorithm was in used and 43,58% when the fuzzy logic one was active. However, a deeper analysis on completed observation (Figure 3b), specifically in the number of reallocation steps, shows that when fuzzy logic algorithm is used the 77% of the completed observation were made by the first telescope the algorithm chose versus the 56% associated to the weather based algorithm. That means that the overall observation time were reduce when using the fuzzy logic algorithm, exactly it was moved from 41 hours to less that 28.

6. CONCLUSIONS

This paper has described the hybrid distributed-centralised architecture of the GLORIA scheduler, as well as the two different telescope decision algorithms that has been implemented and tested in the GLORIA network. A comparative between both algorithms has been made and shows that the fuzzy logic algorithm reduces the reallocation process and thus the overall time to complete the observation.

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