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Dynamic Scheduling in ALMA

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Abstract. In ALMA, the scheduling subsystem will primarily run in a dynamic mode. Algorithmically the scheduling subsystem will determine the best scheduling block to execute at any given moment. Through the use of a scheduling policy, stored in the ALMA archive, the scheduling algorithm calculates a score. This score uses a formula which is constructed using different factors with assigned weights specified in the scheduling policy. This allows the scheduling algorithm to be fine tuned as experience is gathered with weather conditions and different states of the telescope. The flexibility of the scheduling policy and the dynamic scheduling algorithm will be described here.

1. Introduction

The Atacama Large Millimeter Array (ALMA) has the challenge that due to its frequency band ranges, water vapor will have an important role in what can and cannot be observed to get good data. To make efficient use of ALMA's capability under varying environmental conditions, dynamic scheduling has been chosen as the primary mode of scheduling. Being able to determine in near real time what is the best scheduling block to observe right now, given the current conditions, will be the focus of the ALMA dynamic scheduling algorithm. The dynamic scheduling subsystem of ALMA is required to be as flexible as possible. Since observing at the millimeter and sub-millimeter wavelengths is relatively new science it would not benefit the Astronomical community to hardwire a dynamic scheduling algorithm that has little or no ability for optimizations. Therefore, the dynamic scheduler of ALMA needs to be as flexible and tunable as possible. To create this flexibility ALMA intends to implement a Scheduling Policy which is represented in XML. This scheduling policy approach allows the computations within the dynamic scheduler to be configured to use new optimizations gathered through usage of the telescope.

2. Dynamic Scheduling Subsystem Overview

The scheduling system in ALMA will evaluate the scheduling blocks on two levels. The first evaluation will happen before the dynamic scheduler is created. The master scheduler, which manages all subsequent schedulers and has a master queue of scheduling blocks, will group together similar scheduling blocks into a sub-queue. During this evaluation the master scheduler will make sure the targets of the scheduling block are optimally visible for the entire duration of the scheduling block. Also the entire scheduling block must be able to be executed during the available time and the required antennas and hardware resources are available. This sub-queue is then submitted to a new dynamic scheduler with a given scheduling policy. The second level of evaluation for the scheduling blocks happens on this sub-queue. The dynamic scheduler uses the calculations in the scheduling policy to decide which scheduling block should be observed next based on the current conditions. This evaluation happens in near real time and does not focus on the long term conditions of the system.

3. Scheduling Policy

The evaluation of the scheduling blocks that happens in the dynamic scheduler is based on the details of the scheduling policy. The scheduling policy is an xml document that contains a success calculation, a score calculation and ranking calculation. These calculations are equations made up of one or more factors. The factors are also defined in the scheduling policy are associated with a predefined set of factors which the scheduling system knows about. The ALMA system will support more than one type of scheduling policy. There will be several different scheduling policys using a completely different set of factors for each policy.

3.1. Scheduling Policy Factor

A factor is essentially a variable used in the calculations of the scheduling policy. It is defined in xml and contains three elements. First is a name, which is how the factor is referred to in formulas and is fixed. The name refers to a function that is dynamically evaluated under current conditions. Second is a weight, which is used to indicate the relative importance of the factor in the final calculation. The weight can be modified as experience is gained. Finally a description which explains a little about the factor. A few examples of factors which could be used in the the calculations of the scheduling policy include:

- Weather
- Last scheduling block in the project
- Scientific priority
- Is project North American, European or Japanese

3.2. Success probability formula

The success probability formula is a mathematical formula defined using the available factors defined for ALMA. It is a formula used to to calculate the success probability, for each scheduling block, that it will achieve its scientific goals under the current conditions. This calculation is not used to compare scheduling blocks. Each scheduling block gets its own result from this calculation.

3.3. Rank formula

The rank formula is used to order the scheduling blocks in the dynamic scheduler's sub-queue from highest to lowest desirability. This formula will also use a subset of the factors available in ALMA.

3.4. Final score

The final score will usually be a simple formula, such as success time rank. The highest scored scheduling blocks will be considered as the best candidates for the next observation.

References

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