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OPEN TIME PROPOSAL SUBMISSION SYSTEM FOR THE MeerKAT RADIO TELESCOPE

R.L. Schwartz*, T. Baloyi†, S.S. Sithole§
South African Radio Astronomy Observatory (SARAO),
Cape Town, South Africa

Abstract

Through periodic Calls for Proposals, the South African Radio Astronomy Observatory (SARAO) allocates time on the MeerKAT Radio Telescope to the international community to maximise the scientific impact through radio astronomy; while contributing to South African scientific leadership and human capital development.

Proposals are submitted through the proposal submission system, followed by a stringent review process where they are graded based on specific criteria. Time on the telescope is then allocated based on the grade and rank achieved.

This paper outlines the details of the Open Time proposal submission and review process and the design and implementation of the software used to grade the proposals and allocate the time on the MeerKAT Radio Telescope.

INTRODUCTION

The MeerKAT Radio Telescope is a project of the South African Radio Astronomy Observatory (SARAO) [1] under the National Research Foundation (NRF) [2]. Inaugurated in 2017, it comprises interlinked receptors in the Meerkat National Park, located in the Northern Cape, South Africa. It was initially named the Karoo Array Telescope (KAT) and would have only consisted of 20 receptors, however when the South African government increased the budget, a total of 64 receptors were commissioned. For this reason, it was renamed "MeerKAT", using the Afrikaans word "meer", meaning more.

The MeerKAT Radio telescope was born as a precursor to the intergovernmental Square Kilometer Array (SKA) telescope [3] that will combine thousands of receptors and observatory infrastructure in South Africa and Australia. The SKA will be the largest and most powerful radio telescope in the Southern Hemisphere spanning an effective area of 1 million square meters.

As with any other observatory, SARAO offers telescope time through Open Time Calls (OTC). An OTC is the workflow that SARAO utilises in gathering radio observation proposals from astronomers all over the world, which is then followed by a rigorous review process that ultimately produces proposal observations that the MeerKAT telescope will observe for a specific period.

Following the inauguration of the MeerKAT radio telescope in 2017, the first Open Time Call (OTC1) for proposals was launched in 2018/2019 to a select community. OTC1 was a manual process that employed document collaboration tools for numerous tasks, such as recording user information, observation parameters, and tracking the proposal statuses. Consequently, bulk correspondence with persons who submitted proposals was inherently laborious.

Despite the success of OTC1, the complexity and volume of information necessitated a change for the next OTC. Thus, the arduous workflow of OTC1 motivated the design and development of an information system that would cater for subsequent OTCs, and so the Proposal Workflow System (PAWS) was conceived.

This paper aims to describe and explain, on a high level, the inner workings of the PAWS system that is used at SARAO to acquire potential radio observation proposals for the MeerKAT Radio Telescope.

PROPOSAL WORKFLOW SYSTEM

PAWS is a front-facing web application that was developed to aid the process of acquiring observation proposals for the second Open Time Call (OTC2) scheduled for 2020.

The OTC process follows ordered events that are initiated and managed by PAWS. The workflow is as follows:

- Proposals are submitted during the submission period through a collection form.
- A rigorous review process is then initiated to evaluate the science and feasibility aspects of the proposal and provide a numerical score.
- The proposals are then ranked, reviewed and graded by a panel of experts. Based on the reviews, the top proposals are selected to be given time on the telescope within the next year.
- A report is sent out at the end of the review process for each proposal, and those that have been given time are informed to submit their observation plans.
- The Science Operations team records each project's progress and telescope utilisation time to ensure that observation plans match the time allocated during the review process.

DESIGN AND DEVELOPMENT

Requirements and Process

Requirements for PAWS were provided by the Chief Scientist. They were captured and tracked through the Agile project management software called Jira.

A Kanban Agile approach was taken as the development process throughout the project, with the progress tracked on a Jira Kanban board.

* rschwartz@sarao.ac.za
† tbaloi@sarao.ac.za
§ ssithole@sarao.ac.za

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Technologies

An existing development technology stack was used as the basis for the project, using the following frameworks:

- Fronted – Angular Material
- Backend – Python
- Database – ElasticSearch
- Authentication – KeyCloak

Initially, it was also decided to use an existing commercial form builder, Jotform, to create the Proposal Submission Form, for data collection and website load management.

The environment was served locally to reduce cost as SARAO already had the hardware infrastructure.

Security

Authentication and authorisation are important for any digital system, especially being online and public-facing. KeyCloak is used as an authentication proxy to restrict usage of the PAWS system, both for the client side and the backend API, and also provides authorisation to various features of the tool as required by certain users, for example, the reviewers.

An elevated level of access – the PAWS super-user (PSU) – is also provided, but is strictly limited to developers and key stakeholders to ensure that the proposal information remains confidential.

Testing

Due to tight timelines, minimal unit testing was implemented, but there are plans to implement testing procedures in the future. Frequent manual feature testing is performed on a test environment using actual production data, when it becomes available. This test system also necessitated a secure environment to keep the data confidential.

Deployment

The deployment architecture is set up in such a way that new features can be rolled out quickly. Jenkins is used to build the container images, which are then pushed to a container registry. Simply restarting the application services on the production server initiates the deployment of the new images, so the downtime is very minimal.

A staging system is also used to test the deployment images before applying them to production.

States and Actions

Throughout the workflow, proposals are managed and tracked by a state machine as shown in Figure 1. When a proposal is created on the submission system, it starts in a draft state, thereafter progressing through the states of submitted, review, and finally, graded.

A proposal can be deleted by the user while in a draft state. Before the end of the submission period, proposals can be revised, edited and resubmitted. All draft proposals that have not been submitted, are set to the closed state at the end of the submission period.

After submission, if found to contravene the requirements for proposal submission, the PSU user can retract and remove the proposal from the review process.

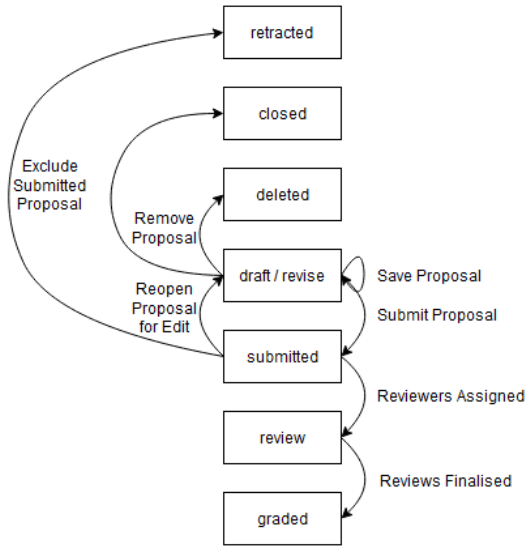

Figure 1: Proposal states and actions.

Dashboard and Statistics

Proposal statistics are displayed via dashboards within the PAWS tools. Viewers are also afforded the functionality to download the statistics in either CSV or PDF format. This information assists in the overall reporting of key areas of the OTC process, as well as being able to track the progress of the individual proposal reviews.

PROPOSAL SUBMISSION FORM

At the start of the Open Call, the Proposal submission system is open to the scientific community, where Principal Investigators (PI) submit proposals indicating the requested time on the MeerKAT telescope.

For OTC2, the proposal submission form was generated using this Jotform form web creation tool, and the data produced was extracted through their API and ingested through our backend service into our ElasticSearch data storage for caching. A basic website was developed for management viewing of the proposal submission data.

During OTC2, the PAWS system developers experienced several issues with the Jotform service that prompted the in-house development of the submission form for OTC3. This also aided in the need for customisability of the form fields for the OTC3 (2022) and OTC4 (2023) open calls.

Some of the proposal submission data that is collected through the submission form includes the following:

- Investigator's details
- Abstract and science case
- Proposal, scientific, and observation categories
- Target information
- Telescope instrumentation parameters
- Data management details

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PROPOSAL REVIEW SYSTEM

Following the closing of the submission period, the submitted proposals enter the review process which comprises several reviews as shown in Figure 2.

The PAWS system renders the review forms to capture and store the review content. It also handles the review workflow and sends out the reports once complete.

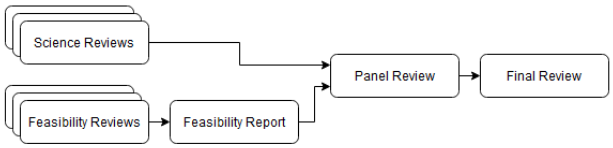

Figure 2: Proposal reviews.

Objective Review Process

Reviews are double-blinded, meaning that the PIs do not know who reviewed their proposals, and the reviewers do not know the PIs of the proposals they are reviewing.

During the Science Review, a score is allocated to the proposal. To attempt to reduce the variations in reviewer grading (i.e. the "easy-grader, hard-grader" problem) and the potential consequences, at the end of the Science Review, these reviewers' scores are normalised based on the mean and standard deviation of all Science Review scores.

Science Review

Many professionals from all over the world volunteer their time to assess the scientific aspects of the proposals. These reviewers rate themselves with regard to scientific categories, and based on these ratings, they are allocated to proposals in the same categories. Generally, each proposal receives about 4 reviewers. Each reviewer evaluates between 10 and 20 proposals, scoring (between 0 and 10) the proposal appropriately and writing a short review.

Technical Review

Concurrent with the Science Reviews, the SARAO Science Operations team of astronomers review the technical aspects of the proposals. They complete a checklist, which includes questions related to sensitivity, overheads, dynamic range, polarimetry, instrumentation, etc.

Feasibility Report

Following on from the Technical Review, the Data Management Plan and Previous Projects declarations, if any, are reviewed and a report is generated to indicate whether the proposal is technically feasible using the MeerKAT radio telescope.

Panel Review

The Science Reviews and the feasibility report are used as inputs to the Panel Review, and the proposals are ordered based on the Science Review score. This information is presented to the Panel, which consists of several specialists who review the proposal-rank listing and adjust the order based on assessment and discussion. A final grading is allocated to the proposals for the coming year, as follows:

- Grade A – proposal will be scheduled on the telescope
- Grade B1 – proposal can be scheduled if there is time
- Grade B2 – proposal has a slim chance of being scheduled if there is spare time
- Grade C – proposal will not receive time

The panel also writes a detailed report to the PI, and may also suggest to SARAO to reduce the time requested for a particular proposal.

Final Review

Finally, the Chief Scientist presents the panel's recommendation to the SARAO Director for final approval.

Following this stringent review process, proposal IDs are generated for the A- and B1-graded proposals. The resulting grades and reports of all proposals are then communicated to the PIs from the PAWS system. The Open Call is then concluded for the period.

Post Open Call

Following the review process, PIs then create Observation Plans, based on their proposals in another system developed by SARAO – the Observation Planning Tool (OPT) [4] – where their observations are then scheduled on the telescope.

To keep track of progress and time for each proposal, the PAWS system also includes a tool to assist the Science Operations team in this regard.

OUTCOMES AND USAGE

Since the start of the implementation of the PAWS system, the number of proposals submitted has increased from 112 in 2020, to 170 in 2023.

This year specifically has seen a drastic increase in the amount of time requested on the telescope, going from 3343 hours in 2020 to 7554 hours in 2023, where the available time in 2023 is only around 1750 hrs. This shows the importance of a good review process, as the volume of information and complexity of the evolving system increases each OTC.

CONCLUSION

It should also be noted that a "cookie-cutter" system is likely not to meet all the needs of the institution regarding a proposal submission and review system, as each year the process changes slightly based on telescope improvements, and therefore more development is constantly needed.

It is evident, though, that this system makes the process of requesting time on the MeerKAT telescope far more manageable, even with the vast amount of work.

REFERENCES

[1] SARAO, https://www.sarao.ac.za/science/meer-kat/

[2] NRF, https://www.nrf.ac.za/

[3] SKAO, https://www.skao.int/explore/telescopes

[4] Observation Planning Tool, https://skaafrica.atlassian.net/wiki/spaces/ESDKB/pages/292356390/