Graph Database Software for Large-Scale Multi-Telescope Experiments

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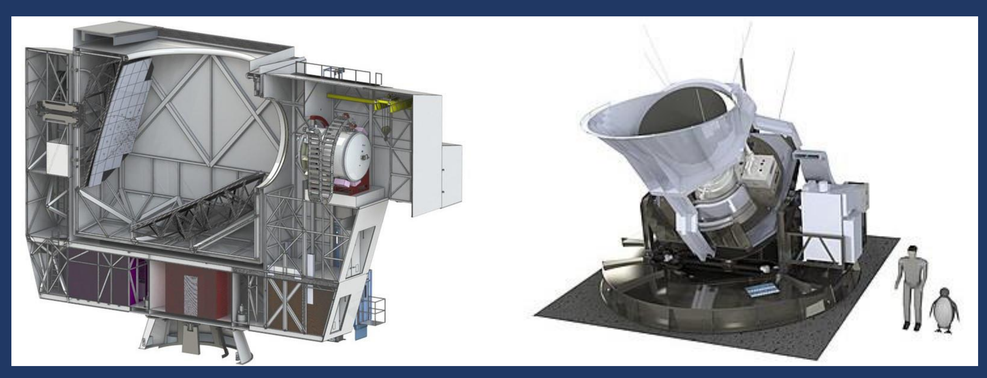
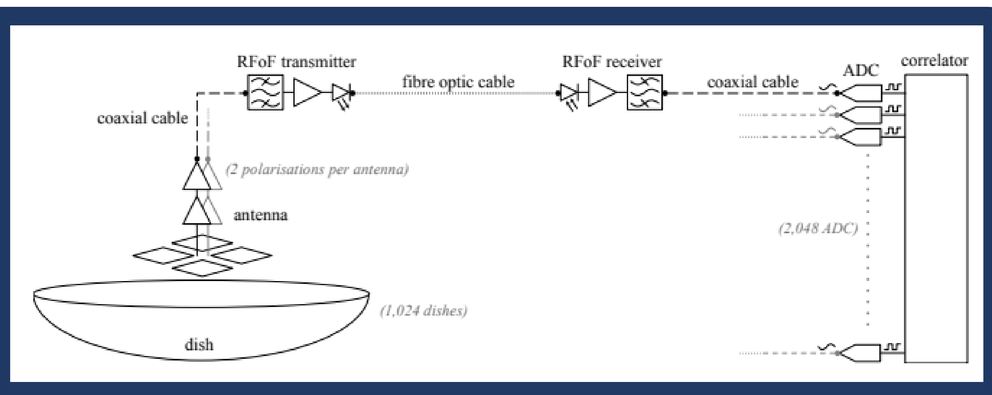
The Simon's Observatory (SO) is a multi-telescope observatory in Chile conducting scientific research on cosmic microwave background (CMB), total mass of neutrinos, and galaxy formation.



The design of the large (left) and small (right) aperture telescopes for SO. Human and penguin for scale. Figures taken from [2] and [3].

The Hydrogen Intensity and Real-Time Analysis eXperiment (HIRAX) is an upcoming array of 1,024 six-meter radio interferometric telescopes in South Africa. Figure below, artist's rendition, taken from [4]. Logo taken from [5].

Science goals include: a 21 cm intensity mapping experiment for the study of dark energy, measuring the baryon acoustic oscillations and use those to measure the expansion history of the universe, detecting and monitoring fast radio bursts and pulsars. It will have well over 2,000 signal chains.

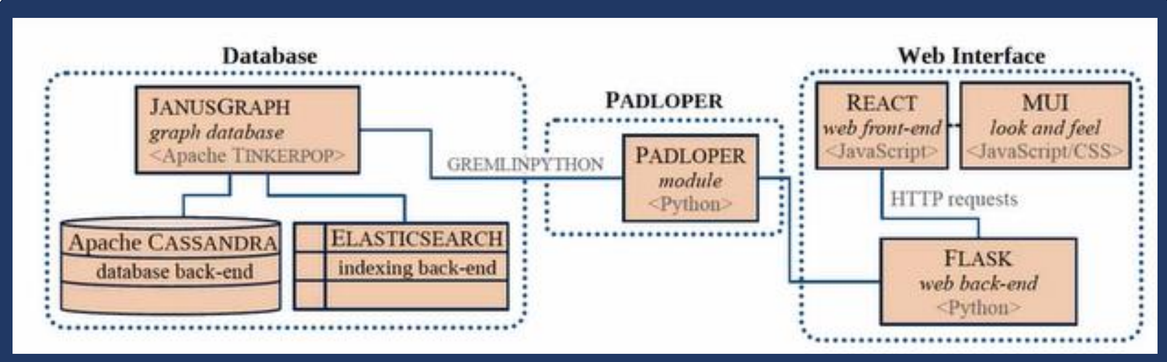


Pictured is a diagram of a signal chain (from HIRAX) depicting not only that there are many distinct physical components involved, but that more can be added, replaced, repointed (dishes) as the experiment grows. Other events may skew data (like weather). This complex bookkeeping task requires specialized software. Figure taken from [6].

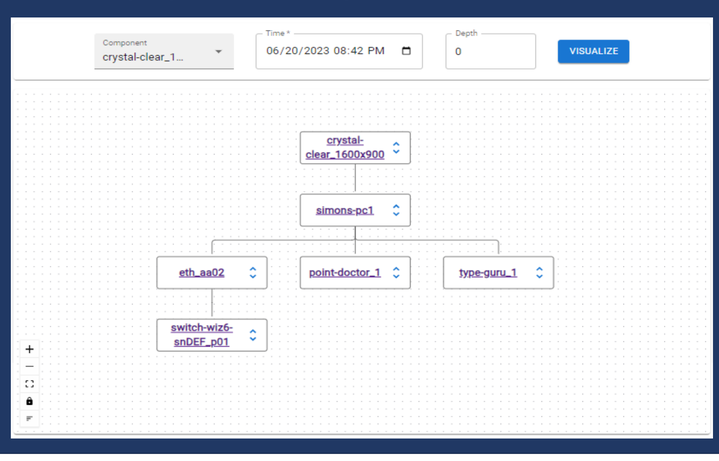
The main issue in large-scale multi-telescope experiments is that there are a lot of physical components, we need to track the configuration of each physical component, and a timestamp of when they move in order to better understand both observations and collected data.

Solution? Padloper!

Padloper is a bookkeeping software that keeps track, lists, and visualizes connections and components in each signal chain. Initially, it was tested what would be a more suitable framework to work with, JsPlumb or ReactFlow. Ultimately, ReactFlow was chosen for its seamless integration with React. Extensive research was done on the Padloper Component Visualizer, more specifically concerning layouts, positioning, dynamically grouping nodes, creating buttons, etc. Ultimately improvements were made in the visualization of connections and physical components in the web interface.



[6] Representation of the Padloper software. Which uses a Janusgraph back-end, a Python module which communicates with the graph database, a Flask server to communicate with the Python module, and Material UI and React for the front-end web interface.



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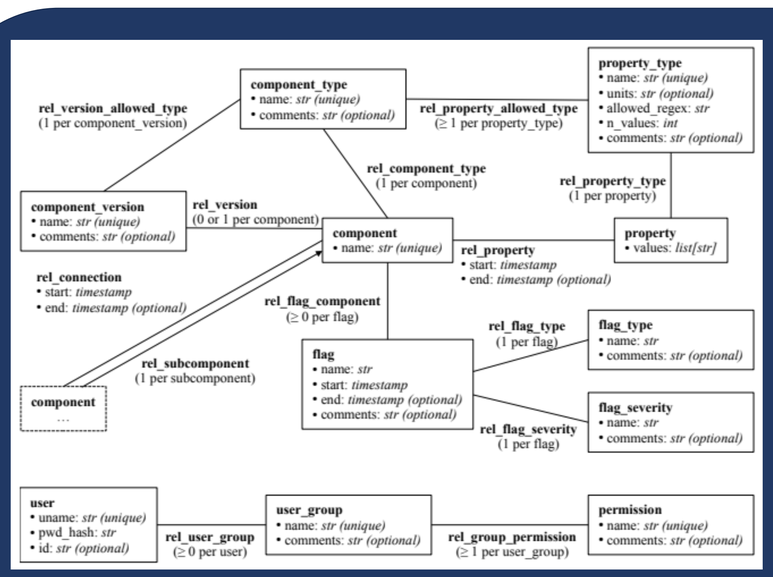

We can timestamp every physical component and connection through a schematic layout diagram. Each piece of hardware is a vertex and each connection is represented by a line. We can attach properties to components for more specific information (ex. where a dish is pointed), and there is a system of flags to keep track of specific time periods for later analysis. Figure taken from [6].

Some possible next steps that could further Padloper's development significantly are:

1. Implementing a functional user authentication system.
2. Implementing a 'see properties' button for each node on the Component Visualizer. While also, implementing tabbing through said node properties.
3. Referencing the history of added nodes via implementing a distinct query string in the URL. Therefore, making the added nodes history a shareable link.

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