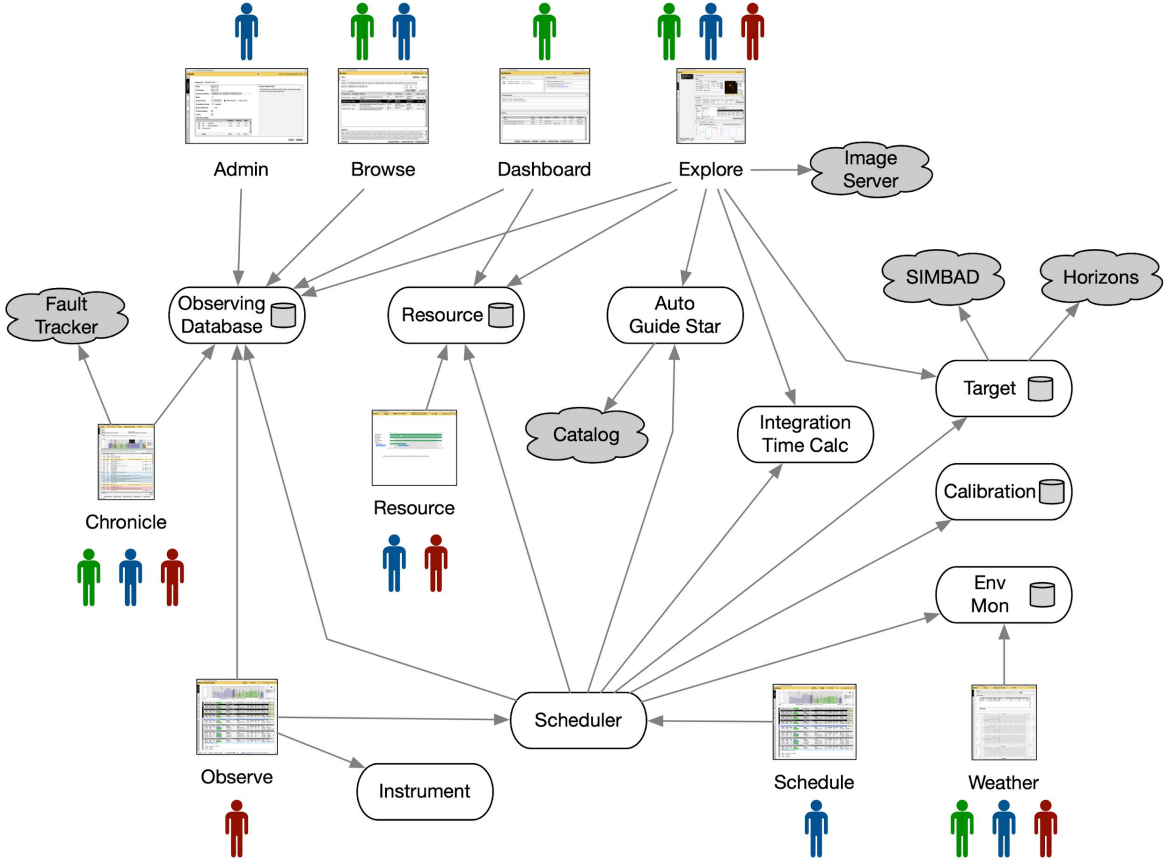
GPP Technology Choices

Replacing a Quarter Century of Cruft

Service Architecture

- GPP is structured as a collection of client web apps communicating with cloud-deployed services using GraphQL queries.
- Allows services to evolve independently and simplifies upgrades.
- Each service may utilize a database to support its persistence requirements.
- Services may use other GPP services or even external services to fulfill requests.


Admin
Browse
Dashboard
Explore
Image Server
Fault Tracker
Observing Database
Resource
Auto Guide Star
SIMBAD
Horizons
Target
Chronicle
Resource
Catalog
Integration Time Calc
Calibration
Env Mon
Observe
Instrument
Scheduler
Schedule
Weather
Uses
UI App
Support Service
External Service
PI
Gemini Staff
Observer

Core Programming Language and Development Paradigm

λ Functional Programming

- Building software by composing and applying pure functions, avoiding shared mutable state.
- A declarative style of programming where expressions are employed rather than imperative statements.
- Why
  - Pure functions are easier to reason about and to test.
  - Encourages reuse yielding reliable, modular systems.
- Alternatives
  - Traditional imperative programming (for example in Java).
  - In our experience building large systems on top of shared mutable state leads to serious maintenance issues.

Scala

- A statically typed, functional programming language on the JVM.
- Why
  - Static typing helps avoid bugs and simplifies long-term maintenance.
  - Builds on the Gemini software team's years of experience on the JVM.
  - Robust ecosystem with ready-made solutions to many common issues.
- Alternatives
  - Eta and Frege are other statically typed functional program languages that target the JVM but both are more similar to Haskell, which is less familiar to the high-level group.
  - Neither has the level of adoption that Scala enjoys.
  - Kotlin + Arrow might be an alternative, but it appears to be less mature and as a team we have invested many years in Scala.

Typelevel Ecosystem

- Suite of modular, pure functional Scala libraries that work together including

Cats	Abstractions for FP in Scala
Cats-Effect	IO Monad and effect handling in general
Doobie	Functional database access
FS2	Stream Processing
Http4s	Functional HTTP client and server library
Monocle	Simplifies reading and updating hierarchical, immutable structures

Typelevel Ecosystem

- Why
  - Scala directly supports functional programming at a superficial level.
  - A foundational library providing abstractions is required (e.g., Functor, Applicative, Monad typeclass definitions, syntax, etc.)
  - The Typelevel Cats library provides this foundation.
  - Having selected a foundation, using functional building blocks that assume the same foundation makes it easier to piece together code.
- Alternatives
  - Scalaz is the only real “competitor” to Cats but the industry has mostly adopted the Typelevel ecosystem.

Front End

Scala.js

- Scala to JavaScript compilation.
- Why
  - Extends Scala to the browser, enabling shared library code across client and server.
  - Static typing in the frontend, simplifying maintenance.
  - Provides interoperability with JavaScript libraries.
  - Freedom to move logic from the backend to the frontend when appropriate.
- Alternatives
  - Clients directly written in JavaScript imply all the computation be relegated to the server, or code must be ported and duplicated across both.
  - JavaScript suffers from maintenance issues common to dynamically typed languages in general.
  - Languages like TypeScript/PureScript would solve maintenance issues of JavaScript, but would also require duplicated code.

Client Side Libraries

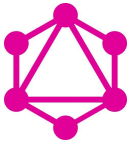
React / scalajs-react	Front end logic structure
Semantic UI	Visual styling
Ag-grid	Advanced tables
Aladin	Catalog visualization
svg components	Instrument visualization

Backend

PostgreSQL

- Free and open source relational database.
- Why
  - Reliable, robust, efficient.
  - Excellent community support.
  - Available as a Heroku service.
- Alternatives
  - Paid alternatives exist but offer no apparent advantages for our needs.
  - Open-source alternatives like MariaDB are available, and would likely suffice, but Postgres is more familiar and Heroku (covered later) offers a managed Postgres service.
  - NoSQL options are not compatible with our emphasis on data integrity and structure.

APIs (Communications)



GraphQL

- API query language used by client web apps and between services themselves.
- Also offered for one-off advanced-user queries and arbitrary scripts.
- Why
  - Clients can specify exactly the information they require.
  - Simplifies API evolution.
  - Supports subscriptions which allow clients to update upon remote changes.
  - Users may write service queries in any language.
- Alternatives
  - Traditional RESTful APIs are an alternative and may be used in some cases.
  - Client has no control over the result and often receives too much data or not enough (requiring additional queries).

Deployment

Heroku

- A continuous and cloud-based deployment service.
- Why
  - Simplifies cloud-platform management over using raw Amazon Web Services.
  - Automates application updates.
  - Provides multiple environments for testing, staging, and production.
  - On-demand resizing and scaling with integrated load-balancing.
  - Tight integration with GitHub for testing and deployment
- Alternatives
  - Amazon Web Services/Google Cloud/Azure offer similar services but expose all the complexity of managing servers and infrastructure.
  - Gemini/NOIRLab does not currently offer cloud based hosting and no managed services over raw VMs.
  - These alternatives become considerably more expensive considering management costs.