

MINDset: A FAIR Infrastructure for Multimodal Neuroimaging Data



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MINDset

- Research platform for **centralized management, integration, and visualization** of multimodal neuroimaging datasets
- Unifies heterogeneous data sources (**MRI, PET, EEG, fNIRS, omics, cognitive & clinical assessments**) into a standardized ecosystem
- Incorporates robust **metadata structuring** to ensure interoperability
- Supports **FAIR data principles** across the research data lifecycle
- Scalable infrastructure using secure **cloud/Kubernetes** architecture for high-volume datasets
- Optimized for **AI/ML workflows**, including multimodal foundation models, RAG, and automated preprocessing
- Provides **user-friendly querying, filtering, and visualization tools** for interactive data exploration

Architecture

- **Modular, cloud-native architecture** designed for scalability, reliability, and secure multimodal data access
- **Streamlit-based web interface** enabling intuitive exploration of studies, metadata, multimodal visualizations, and dataset retrieval
- **FastAPI backend** managing API requests for study queries, metadata extraction, and generation of interactive visual analytics
- **MongoDB database** layer storing structured metadata (JSON/odML) and supporting flexible, high-performance search across modalities
- Containerized components (web app, backend, database) deployed on **FZ Jülich JuCloud**
- **Kubernetes orchestration** for automated scaling, load balancing, and continuous availability of application services
- **OAuth2 Proxy** integration, securing user authentication and controlled access to sensitive neuroimaging data
- **GitLab CI/CD** pipelines automate building, testing, and deployment of application containers, ensuring reproducibility and rapid updates

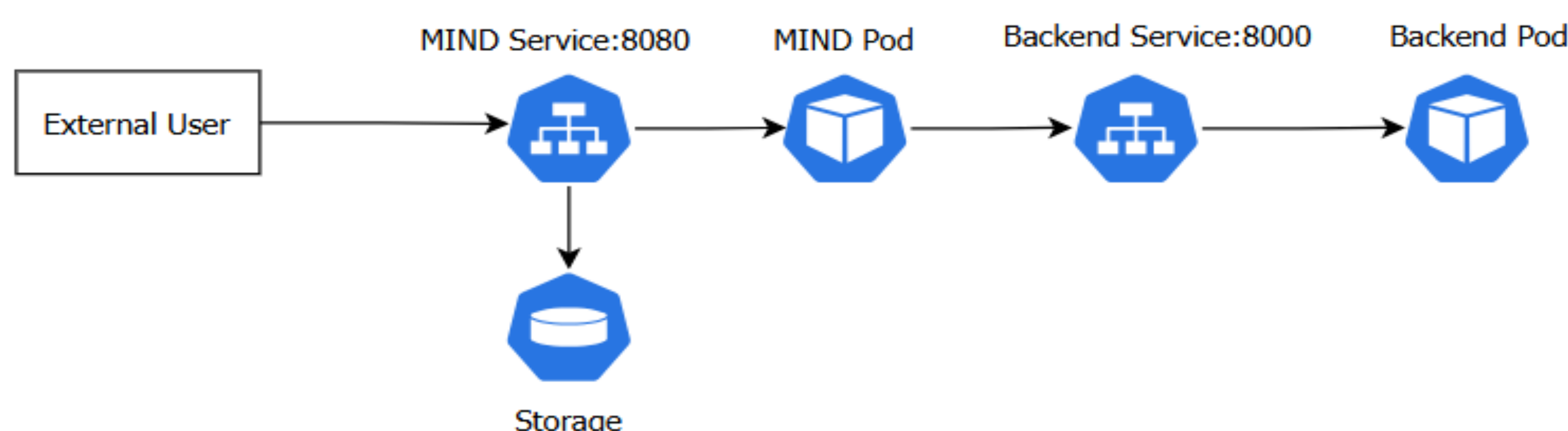


Fig. 1: Shows the workflow diagram for the underlying Kubernetes architecture in the MIND application.

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Key Components

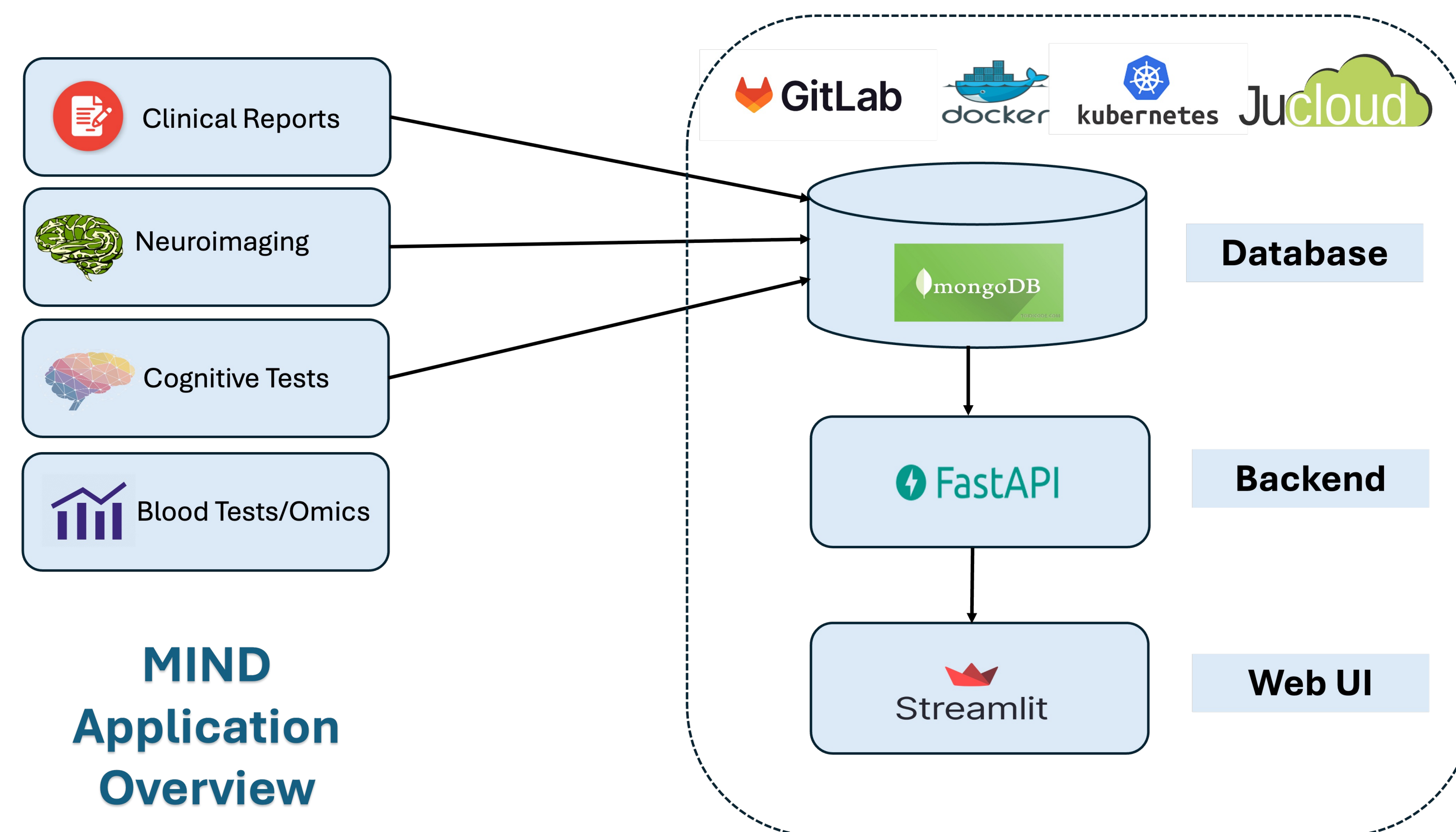


Fig. 2: A schematic diagram showing the main components involved in the MIND application. © Syed Muhammed Ali & Ravichandran Rajkumar all rights reserved.

Key Features

- **Study explorer** to Browse/filter study metadata and select attributes for instant visualization
- **NIfTI Image viewer** to load NIfTI images with overlays
- **Interactive visualization** to plot metadata/cognitive/imaging scores
- **LLM-based patient report generator** from multimodal data*
- **rTMS hotspot indicator** for precision treatment targeting*
- **Study dashboards** summarizing data completeness & metrics*
- **Data quality reporter** for automated QC checks*
- **Integrate** automated data analysis pipelines*
- **Stats explorer** for rapid descriptive statistics*

*Features under development

Outlook

- Open **MINDset to additional groups** and imaging facilities
- **Integrate more modalities** (omics, electrophysiology, behavioural data) into the BIDS/FAIR framework
- Add **automated** multimodal preprocessing and harmonization pipelines
- **Expand AI stack:** foundation-model adapters, RAG search, explainability tools
- **Build AI-ready data layers** (vector search, embeddings...)
- Collaborate with **RSE and NFDI partners** to develop sustainable tools, harmonized metadata standards, and interoperable FAIR workflows.
- **Grow MINDset into a scalable, secure hub for multi-centre precision psychiatry with additional funding.**