PrivateAIM´s FLAME GMDS 2025

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Conflict of interest

The authors declare no conflict of interest.

Content of presentation

TOP 1 - Introduction PrivateAIM

TOP 2 - PrivateAIM's FLAME platform

TOP 3 - Security & Privacy

TOP 4 - Policies & Permissions

TOP 5 - Survey & Discussion

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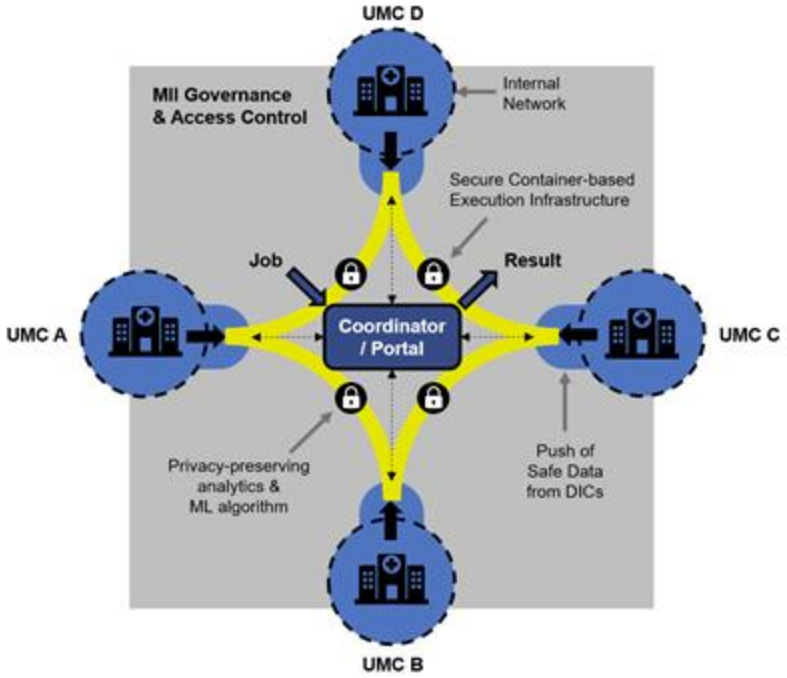
Key Ideas

- Make major contributions in
  - Methods for federated machine learning
  - Privacy guarantees for federated analytics
  - Real-world platform for privacy-preserving analytics
- Deploy these ideas in a consistent platform across the MII sites
- Support other (clinical) use cases within the MII with the platform



PrivateAim Consortium

- 15 Participants from all four MII consortia (and beyond)
- Coordinators
  - >Oliver Kohlbacher (U Tübingen)
  - >Fabian Prasser (Charité)
  - >Daniel Rückert (TU Munich)
- Three associated junior research groups
  - Mete Akgün - Medical Data Privacy and Privacy-Preserving ML on Healthcare Data (MDPPML) (Tübingen)
  - Michael Kamp – Trustworthy Machine Learning (Essen)
  - Björn Schreiweis – Medical Informatics (Kiel)

Charité - Universitätsmedizin Berlin (Charité)	Prof. Dr. Fabian Prasser
Helmholtz Center for Information Security (CISPA)	Prof. Dr. Mario Fritz
Deutsches Krebsforschungszentrum (DKFZ)	Dr. Ralf Omar Floca
University of Tübingen (EKUT)	Prof. Dr. Nico Pfeifer
Ludwig-Maximilians-Universität München (LMU)	Prof. Dr. Ulrich Mansmann
Technology, Methods, and Infrastructure for Networked Medical Research (TMF)	Sebastian C. Semler
Technische Universität München (TUM)	Prof. Dr. Daniel Rückert
Friedrich-Alexander-Universität Erlangen-Nürnberg (UKER)	Prof. Dr. Thomas Ganslandt
University of Freiburg (UKFR)	Prof. Dr. Harald Binder
University Hospital Heidelberg (UKHD)	Prof. Dr. Christoph Dieterich
University of Cologne (UKK)	Prof. Dr. Oya Beyan
Leipzig University Medical Center (UKL)	Prof. Dr. Toralf Kirsten
University Hospital Tübingen (UKT)	Prof. Dr. Oliver Kohlbacher
Ulm University (UKU)	Prof. Dr. Hans Kestler
Medical Faculty Mannheim, Heidelberg University (UMM)	Prof. Dr. Martin Lablans

FLAME Platform

Federated **L**earning and **A**nalyses in **Me**dicine FLAME

The FLAME platform integrates proven technologies (PADME & PHT-meDIC) to provide a robust framework for medical data analysis, ensuring security and compliance while advancing research and data privacy. The platform is open-source available.

Repositories https://github.com/PrivateAIM

Info page https://privateaim.de/

Documentation https://docs.privateaim.net/

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FLAME Analysis

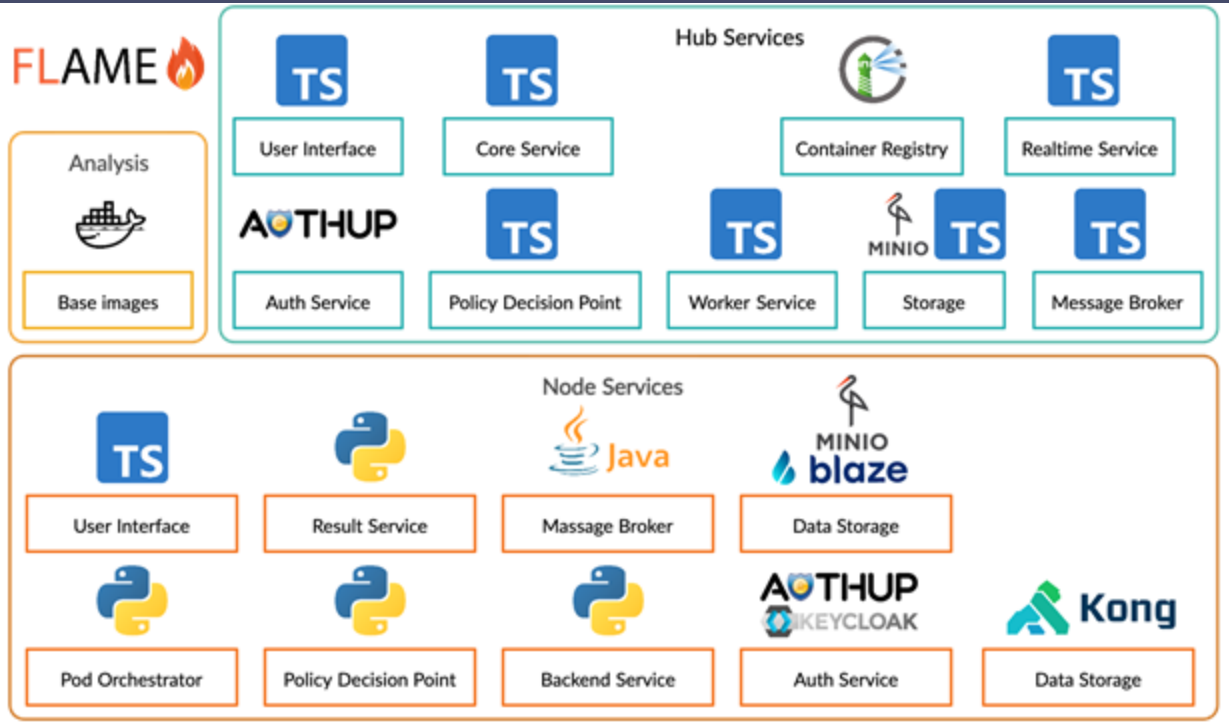
General

- Based on Docker and Master Images (software dependencies)
- Multi round communication between nodes possible
- Aggregation and analysis functions contained in one bundle
- Currently support: Python and R - technical no restriction

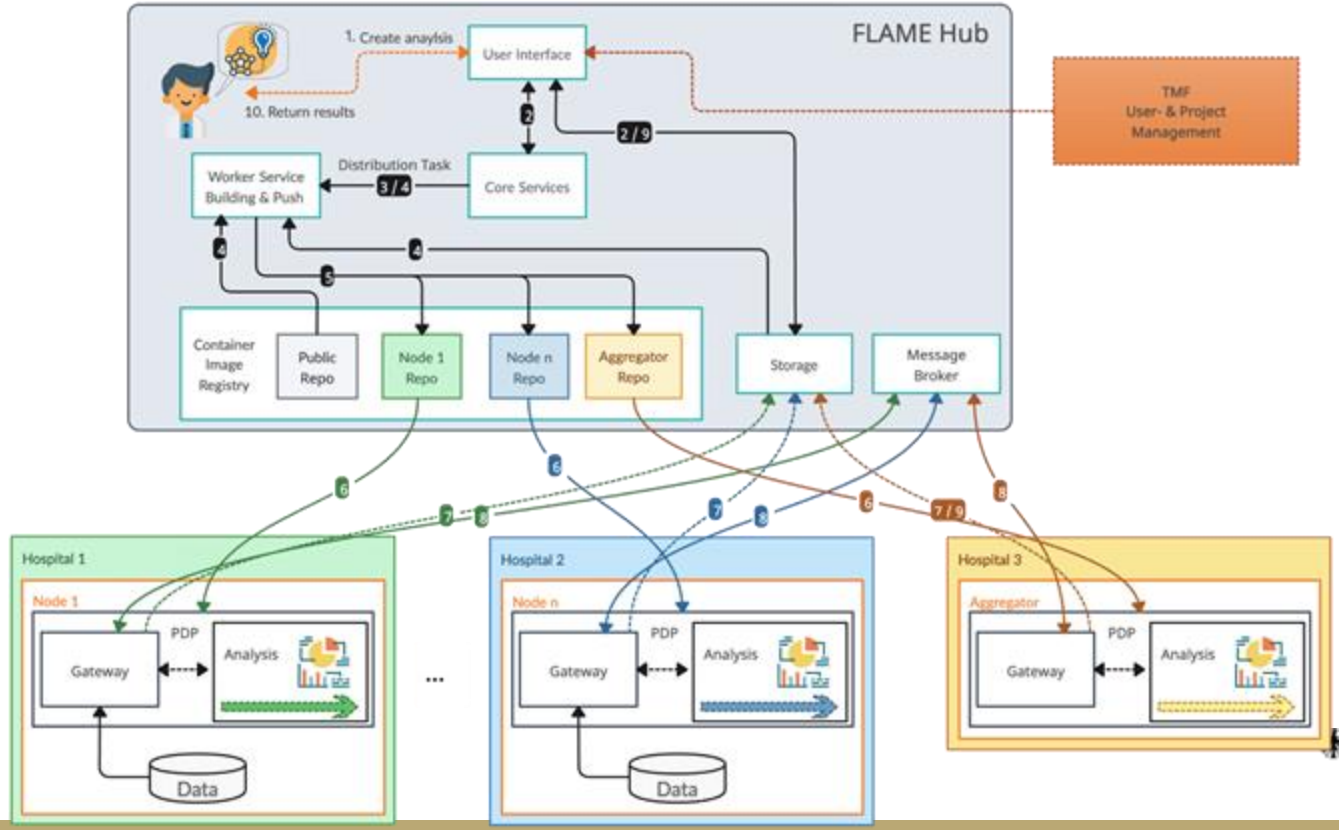
Analysis written with FLAME-SDK

- Different analysis patterns possible (star model, site-to-site, decentral)
- Input / Output communication only over protected endpoints and APIs
- Reusable and modular adjustable

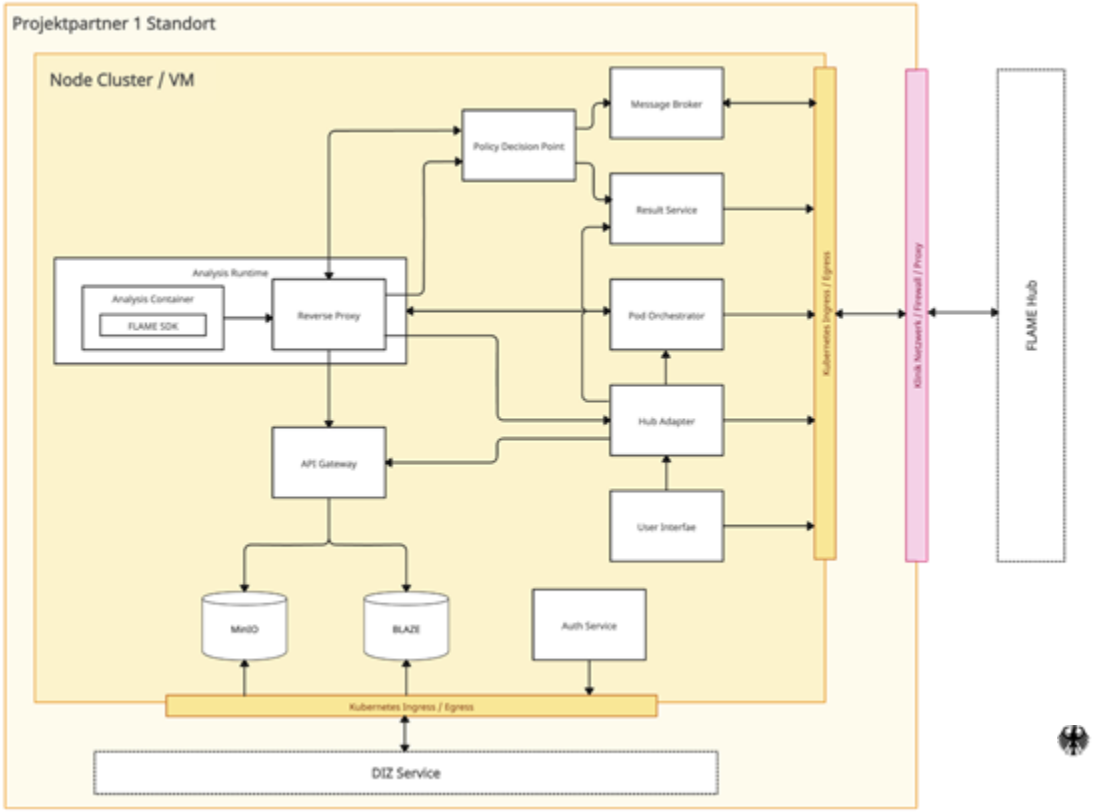
Service Components



Simplified analysis execution



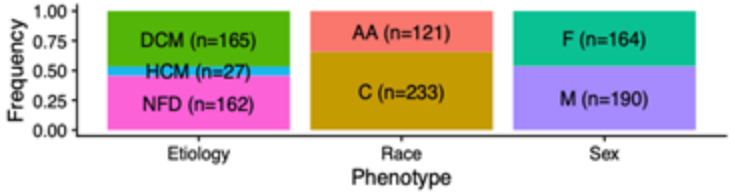
Node Data Flows



Use Case 1 - Gene expression + phenotype study data

Data

- Clinical phenotype study data (366 individuals)
- Gene expression data from Magnetique database
- Public available datasets mapped to FHIR



Analysis

- Analysis in R (executed from Python) distinguishing subjects into DCM, HCM and NFD groups and biomarker discovery
  - **Dilated cardiomyopathy** (DCM) is a disease of the heart muscle
  - **Hypertrophic cardiomyopathy** (HCM) is a disease in which the heart muscle becomes abnormally thick
  - Non-Failing donor (NFD)

Use Case 2 - Genome-wide association Study - current (current)

DNA sequencing data

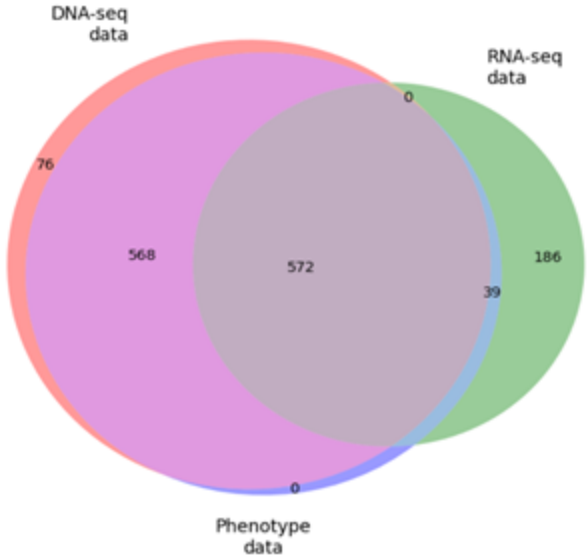
- Whole Genome sequencing ~1,200 samples

RNA sequencing data

- PaxGene Blood ~800 Samples

Clinical phenotype data

- Physical features (Age, Sex, Weight, etc.)
- Clinical features (Blood pressure, Hypertension, etc.)
- Medication (Name, Dosage etc.) ~1300 Samples



Federated dataset: Data from apparently healthy individuals are gathered from multiple clinic centers across Germany

Multimodality: Dataset contains several different types of data

FLAME Security

Software Dependencies

- Analyses are based on master images (approved by us)
- CVE scans

Analysis and Project approval

- Analyses must (*currently*) be manually approved and initiated by each site

Encryption

- All communication is encrypted via SSL/TLS

Authorization and Authentication

- All flows are protected and controlled

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FLAME Privacy

PETs (Privacy Enhancing Technologies)

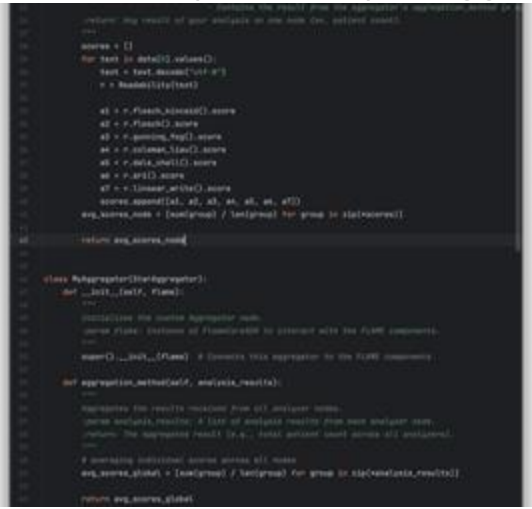
- Different levels of PET integration, from analyst-controlled to fully system-enforced protection.
  - Bronze: Integrated by the user
  - Silver: From SDK ensured
  - Gold: On the API level integrated
- Scalable, auditable, and policy-driven privacy safeguards across the data lifecycle.

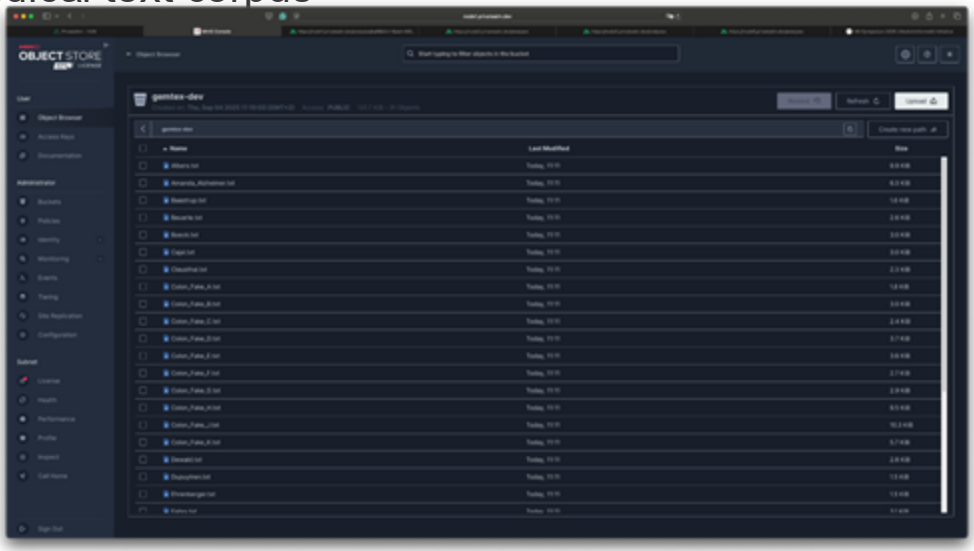
FLAME Analysis: GeMTeX Showcase

Data: GRASCCO - The First Publicly Shareable, Multiply-Alienated German Clinical Text Corpus[1]

Analysis: Calculate readability score of medical text corpus[2]

Setup: 2 Nodes (half data) 1 Aggregator





[1] Modersohn L, Schulz S, Lohr C, Hahn U. GRASCCO - The First Publicly Shareable, Multiply-Alienated German Clinical Text Corpus. Stud Health Technol Inform. 2022 Aug 17;296:66-72. doi: 10.3233/SHTI220805. PMID: 36073490.
[2] Thank you to Andreas Daul - meDIC Tübingen

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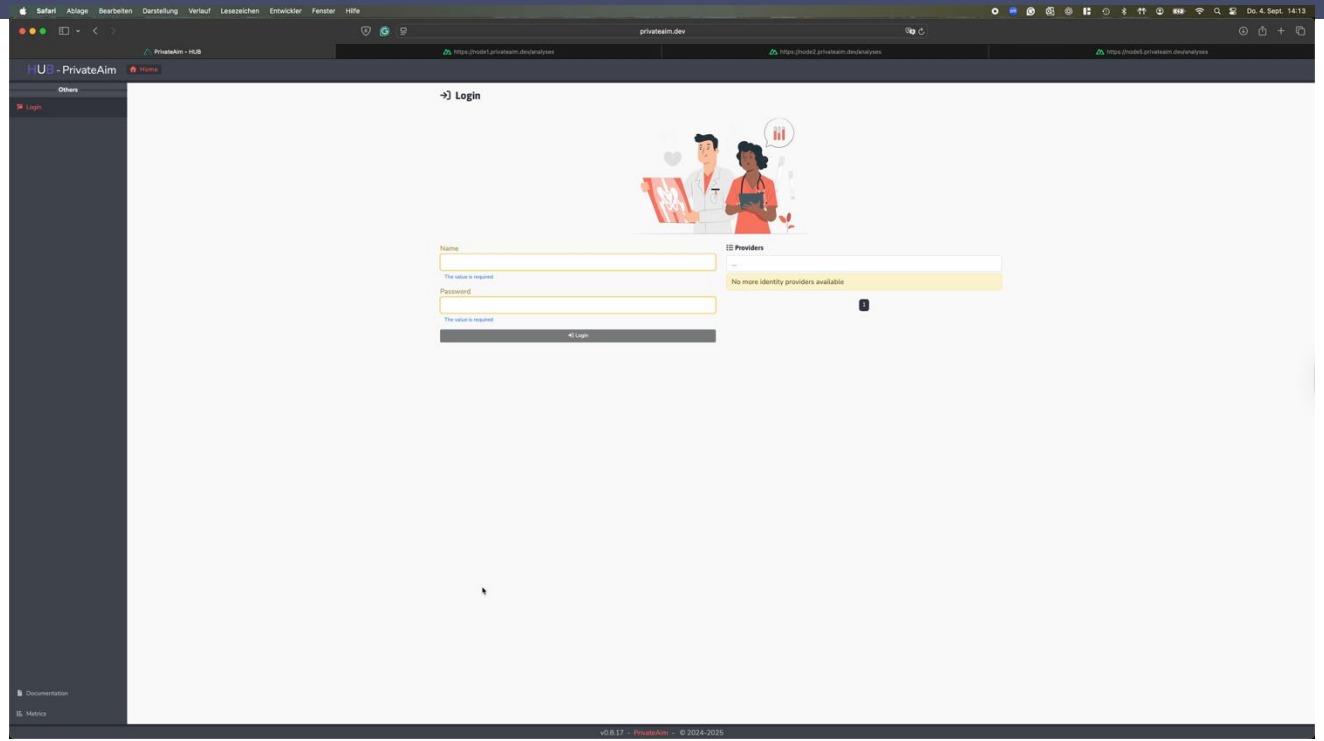
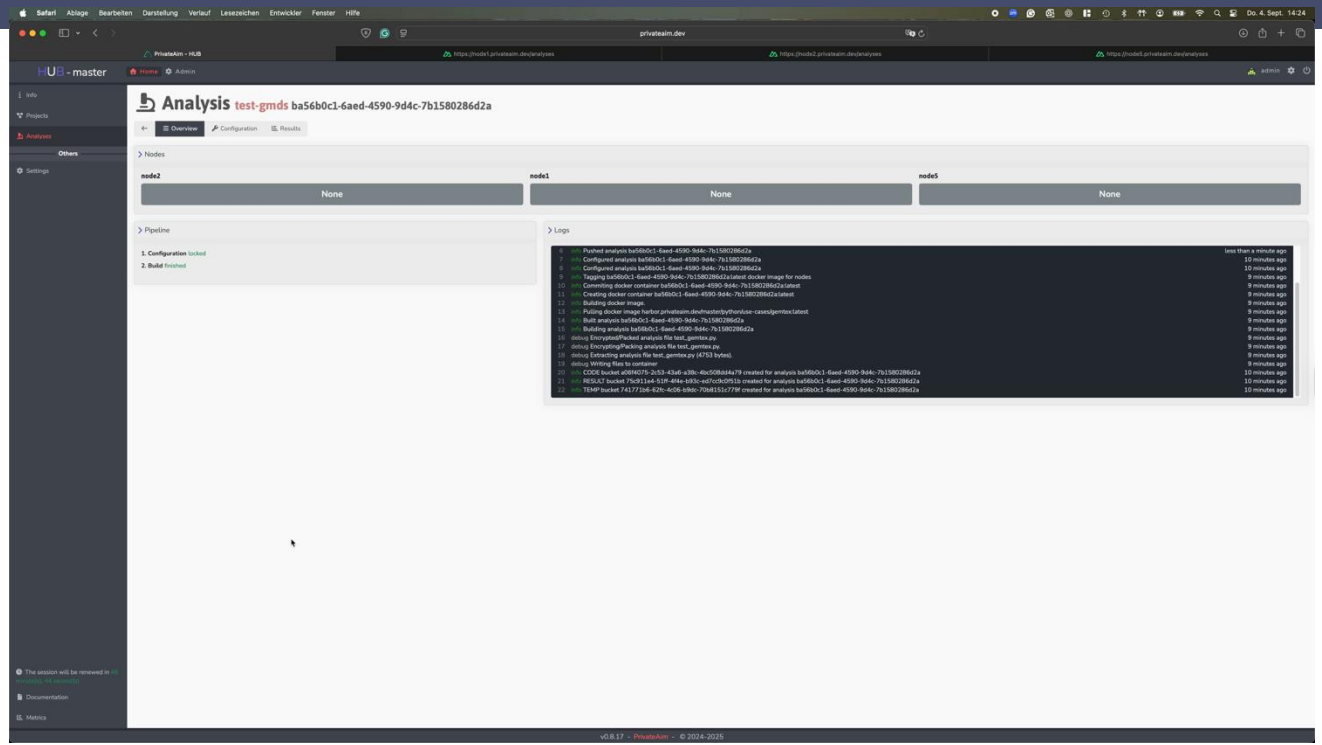
FLAME Analysis: GeMTeX Submission



FLAME Analysis: GeMTeX Execution & Results



Current status

Platform

- Test deployment at leading DIC (3 / 4) 🔄
- First methods integration and Use Case 1 ✓
- Stability and last features for prod. deployment 🔄

Privacy

- Specification and implementation guide for privacy models ✓
- Integration of first PETs & Permissions and Policies 🔄

Governance / Legal

- Deployment document templates (in review) 🔄
- Privacy protection guideline ✓
- Prod. deployment at leading DIC 🔄

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Permissions

Definition

A permission (<Entity>_<Action>) represents an ability, that defines what an **actor** (user, client, robot, …) may do

Components

- **Entity** targeted by the action (e.g. datastore, service, log)
- **Action** to perform (e.g. access, read, write)

Categories

- Node
- Universal
- Hub

Policies

Definition

A policy

- restricts a permission by specific conditions
- consists of a specification (parameterization) and an evaluator

Categories

- General Policies (time, date, attributes, …)
- Virtual Resource Policies (storage, logging, …)
- Physical Resource Policies (hardware, …)

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Framework: Components

Policy Distribution Point (PDiP)

- provides policy configurations to PE

Policy Information Point (PIP)

- provides additional information for policy decisions (linkage permission & analysis)

Policy Engine (PE)

- container for different policy configs
- evaluates different configurations (from PDiP & PIP) for a given policy

Policy Decision Point (PDP)

- uses Policy Engine (PE) for evaluation
- core point for decision logic

Policy Enforcer (PE)

- implements PDP/PE decisions in practice
- implementation varies by service

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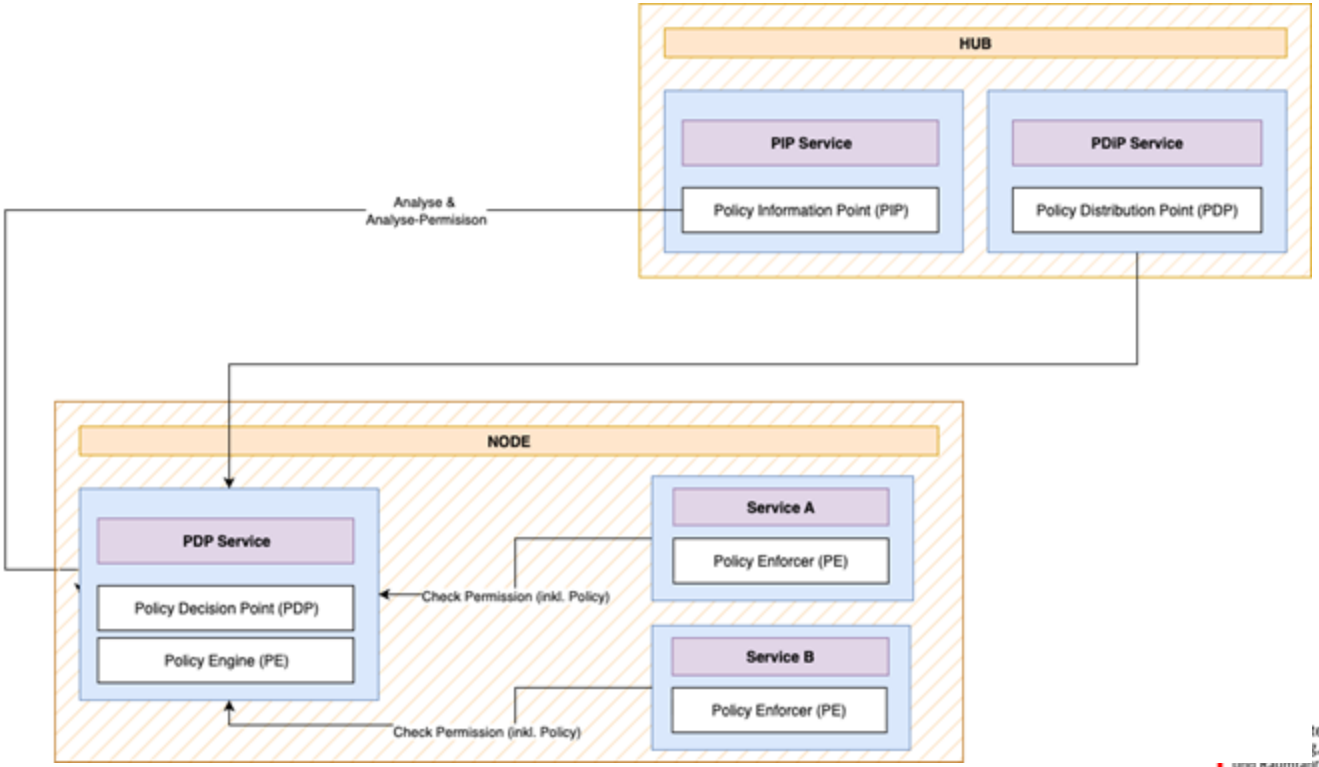
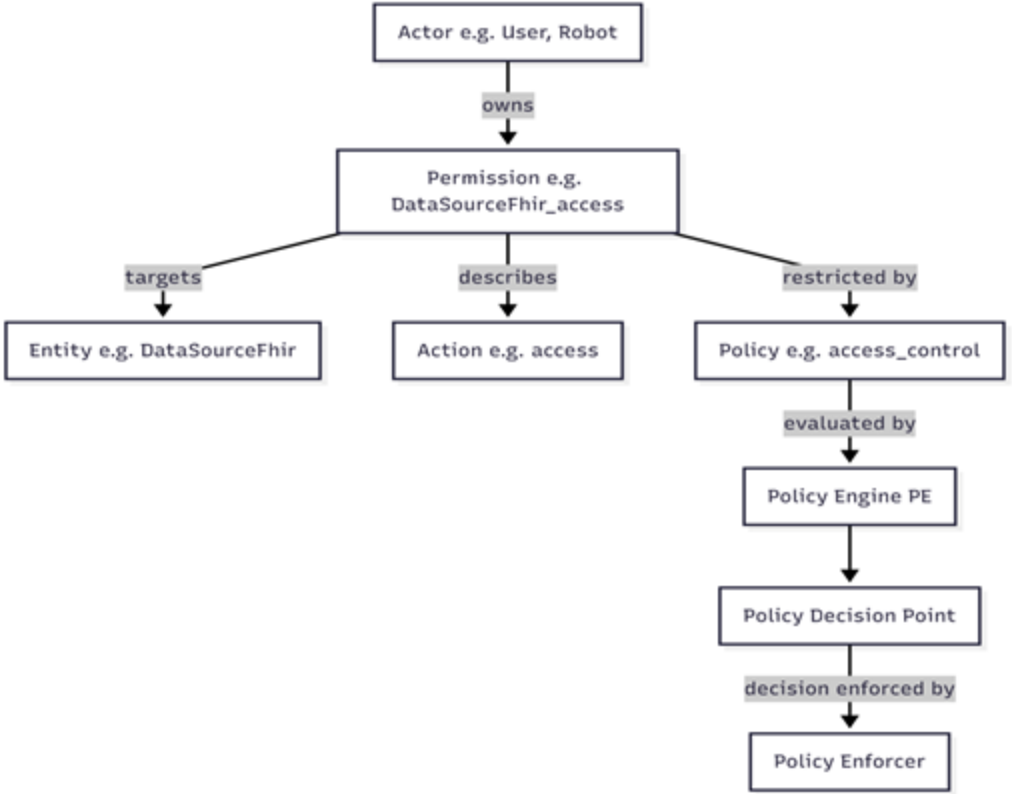
Framework: Architecture



Permissions & Policies



Discussion

- General
- Architecture
- Policy & Permissions
- Results of mentimeter

Thanks

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Birgit Heinz

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Paul Brassel
Jugl Maximilian

David Hieber
Alexander Röhl

Mete Akguen
Cem Baykara

Raphael Rehms

Lena Raber
Nayeli Anaid
Ipek Uguner

Patric Tippmann

Marlena Mayer
German Sergei

Questions?