BCSE497J Project-I

Zero-Trust Cloud Collaboration Platform

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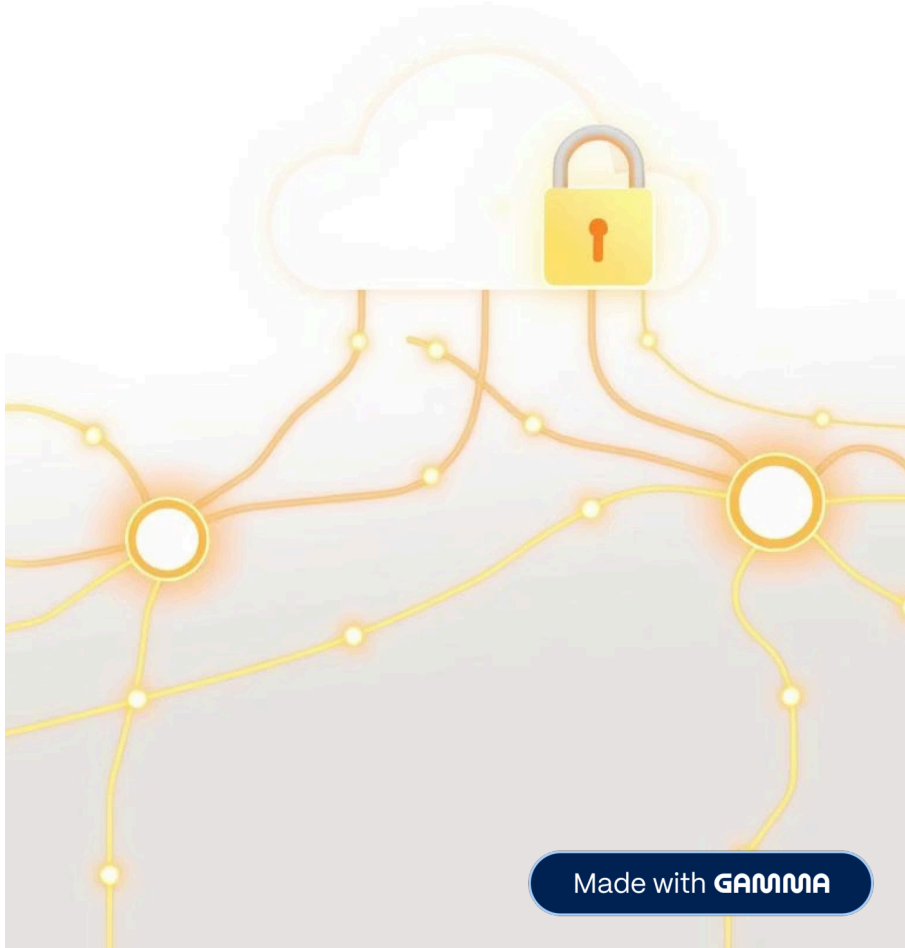


Literature Review: Foundations of Zero Trust

Our platform's design is informed by cutting-edge research in Zero-Trust architectures and cloud security. We've synthesized key insights from leading academic and industry publications to build a robust and adaptive solution.

Zero Trust Architecture: A Systematic Literature Review

Explores adaptive access control and contextual decision-making in cloud environments.

Implementing Zero Trust Security Models in Cloud Computing

Reviews zero trust deployment strategies and operational challenges in cloud.

Redefining Zero Trust Architecture in Cloud Networks

Discusses dynamic, granular, and context-aware policy enforcement for cloud security.

Comparing Feature-based and Context-aware Approaches to PII Generalization

Evaluates context-aware models for accurate PII detection.

Anomaly Detection in Cloud Computing

Systematic review of machine learning techniques for proactive threat identification in the cloud.

Addressing Critical Gaps in Cloud Security

Our research identified key limitations in existing cloud security paradigms. The Zero-Trust Cloud Collaboration Platform is specifically designed to overcome these challenges, ensuring a more dynamic and intelligent security posture.

→ Static Access Policies

Fail to adapt to evolving user contexts, roles, and environments, creating vulnerabilities.

→ Surface-Level PII Detection

Overlooks nuanced, context-sensitive risks, leading to potential data breaches.

→ Lack of Real-Time Integration

Limits proactive security for policy enforcement and behavioral anomaly detection.

Our Strategic Objectives

The development of the Zero-Trust Cloud Collaboration Platform is guided by a clear set of objectives, focusing on modularity, intelligence, and real-time responsiveness.

01

Modular Cloud Platform

Build a modular, microservice-ready cloud platform that ensures continuous, context-sensitive verification.

02

Automated PII Classification

Implement automated, context-aware NLP-based PII and sensitivity classification for uploaded files.

03

Adaptive Policy Engine

Develop an adaptive Zero-Trust Policy Engine for informed access decisions based on multiple dynamic factors.

04

Behavioral Anomaly Detection

Integrate behavioral anomaly detection using ML to spot and respond to insider and external threats in real time.

05

Live Visualization Dashboard

Provide a demo-ready dashboard for live visualization of access logs and security alerts.

Platform Specifications: Hardware

Our platform is designed for flexibility, supporting both development and scalable deployment environments with robust hardware requirements.

Development Machines

- Standard x86-64 architecture systems
- Minimum Quad-core CPU @2.0 GHz
- 16GB RAM, SSD storage (256GB+)
- Ethernet/Wi-Fi connectivity
- Supporting container runtime (Docker)

Server Deployment

- Linux VM (Ubuntu 22.04 LTS or CentOS 8)
- 4 vCPU, 16GB RAM, 200GB SSD
- Scalable up to cluster environments
- Trusted LAN/VPN and untrusted public IP ranges
- NAT/firewall configurations for Zero Trust scenarios

Platform Specifications: Software Stack

A comprehensive and modern software stack underpins our Zero-Trust platform, leveraging open-source tools for efficiency and scalability.

Backend & Infrastructure

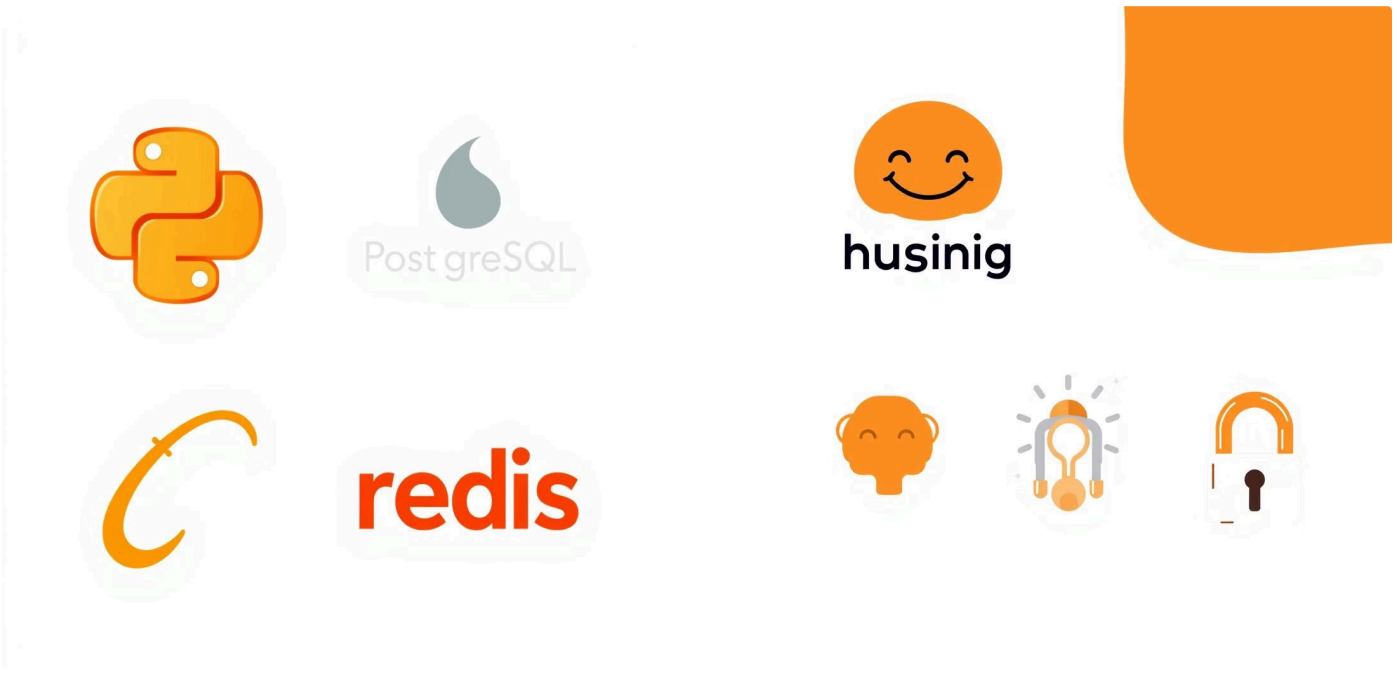
- Python 3.9+ (FastAPI framework)
- Docker Compose
- Celery (task queue)
- PostgreSQL 13+
- Redis 6+

AI/ML & Security

- Hugging Face Transformers (DistilBERT/RoBERTa)
- scikit-learn (Isolation Forest)
- WebAuthn (FIDO2) libraries
- JWT tokens

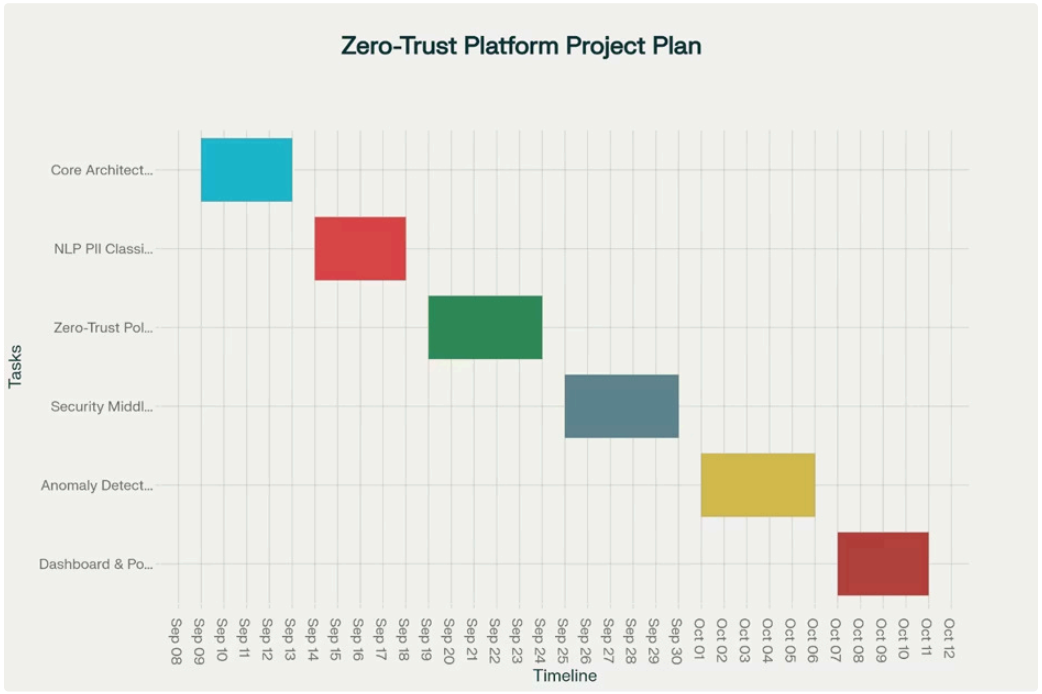
Frontend & DevOps

- React.js/Vue.js (latest)
- Chart.js/D3.js for dashboard visuals
- Git, CI/CD tools (GitHub Actions/CI)
- VS Code/PyCharm IDE
- Nginx (reverse proxy)
- REST API tools (Postman)
- Testing frameworks (pytest, unittest)



Gantt Chart with Work Breakdown Structure

This Gantt chart visualizes timelines, task dependencies, and weekly milestones. Below is a project schedule (September–October 2025):



The project spans approximately 14 weeks total, with sequential phases building upon each other. Each colored bar represents a different project component with specific start and end dates.

Week	Task	Subtasks
1	Core Architecture & Auth	Docker Setup, WebAuthn, File API development
2	NLP PII Classifier	Hugging Face, Model tuning, Celery background
3	Zero-Trust Policy Engine	Context vectors, Policy rule encoding
4	Security Middleware	API interception, Policy enforcement
5	Anomaly Detection	Logging, Data simulation, Isolation Forest ML
6	Dashboard & Final Polish	Dashboard design, Alerts, Documentation

Requirement Analysis: Functional Capabilities

The platform's core functionalities are designed to provide comprehensive security and seamless collaboration within a Zero-Trust framework.

1

Secure User Authentication

Via passwordless WebAuthn for enhanced security.

2

File Management APIs

Upload, download, list, delete with strict user validation.

3

Background File Classification

Using NLP for PII and sensitivity levels.

4

Dynamic Policy Enforcement

Allow, deny, read-only via Zero-Trust engine.

5

Real-Time Monitoring

Activity logging and anomaly detection alerts.

6

Responsive Dashboard

For access decisions and threat notifications.

Requirement Analysis: Non-Functional & Constraints

Beyond core features, the platform adheres to critical non-functional requirements and operates within defined project constraints to ensure quality and timely delivery.

Non-Functional Requirements

Scalability

Modular microservice architecture supporting load balancing and container orchestration.

Reliability

Robust error handling and transaction logs for data integrity.

Usability

Clean UI/UX for dashboard, fast API response for user satisfaction.

Security

End-to-end encryption (TLS), strict context-aware access control.

Compliance

Designed for GDPR and other regulatory frameworks.

Project Constraints

Open-Source Preference

Prioritizing modern, open-source libraries and tools.

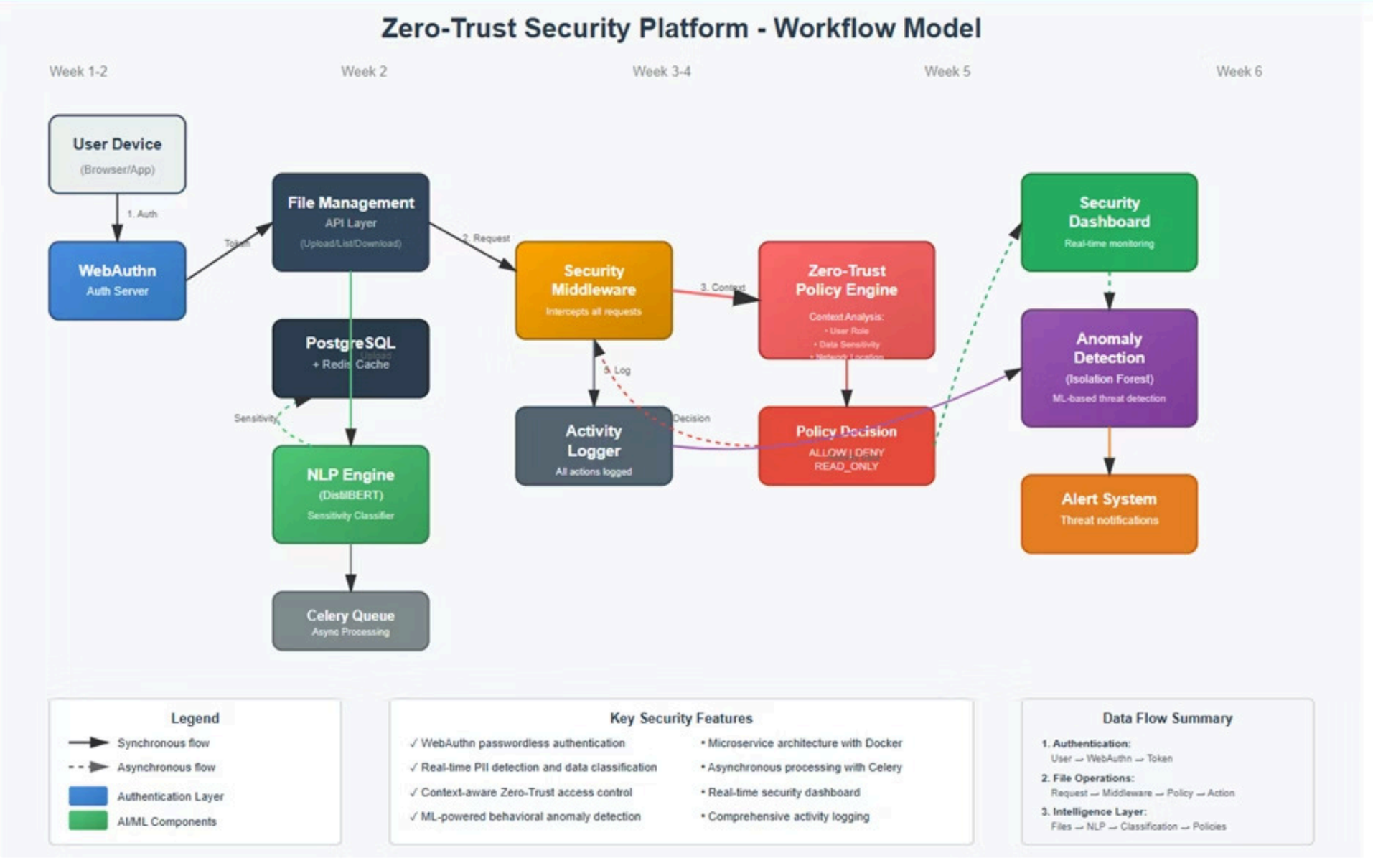
Timeframe

Project delivered within 1.5 months.

Deployment Flexibility

Cloud-ready or on-prem deployment options.

Workflow Model



Module Design & Implementation: Week 1 Focus

The initial phase of development focuses on establishing the core architecture and foundational security mechanisms.

Docker-based Service Architecture

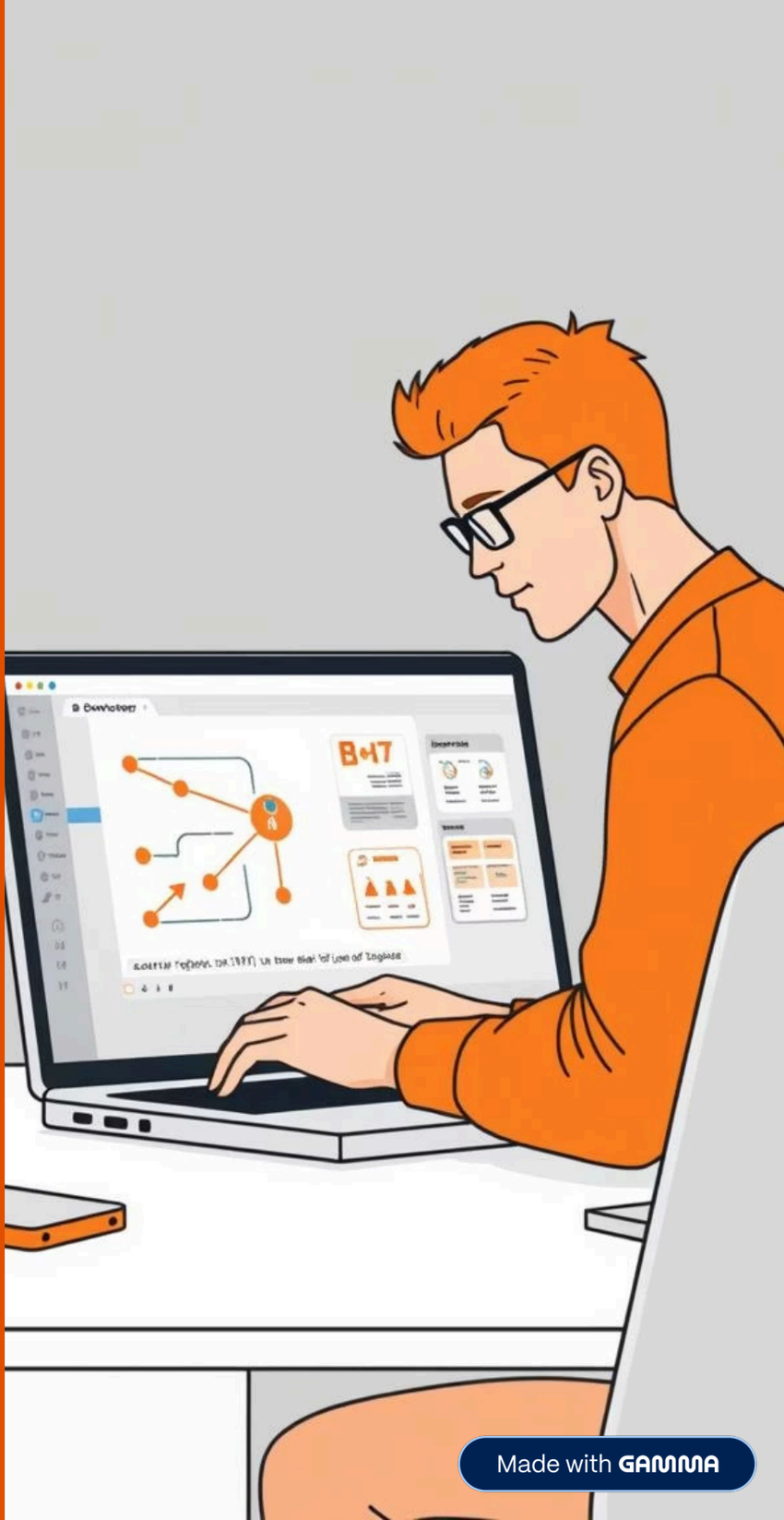
Python backend, PostgreSQL (users/files), Redis (cache, Celery broker). Compose files with clear service boundaries, network isolation.

WebAuthn Integration

Registration, login endpoints, public key cryptography, FIDO2 libraries. JWT token issuance after authentication.

File Management APIs

Endpoints: `/upload`, `/list`, `/download`, `/delete`. User ownership checks on all ops, error handling for missing/wrong files.



Module Design & Implementation: Week 2 Focus

Building on the core, Week 2 introduces intelligent data classification capabilities, crucial for context-aware security.

1

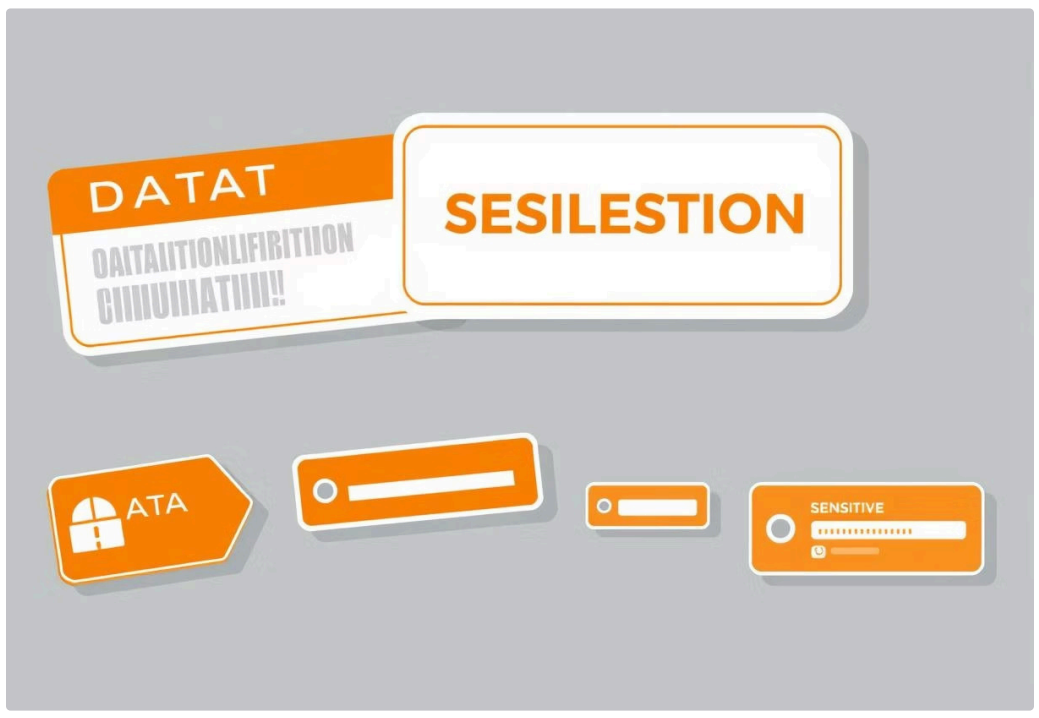
NLP Service Integration

Integration of Hugging Face Transformers (DistilBERT/RoBERTa). API route to ingest and asynchronously classify files for PII.

2

Data Classification Module

Assign sensitivity (**Public**, **Internal**, **Confidential**, **Restricted**) in DB models.



3

Celery Task Integration

Asynchronous background processing for classification, decoupled from API latency. Regular updating of the file's sensitivity tag in the database.