

# **Advanced QBank System v10 - Enterprise Edition**

## **Project Structure**

qbank/

- |— README.md
- |— docker-compose.yml
- |— .env.example
- |— .github/
  - |— workflows/
    - |— backend-ci.yml
    - |— admin-ui-ci.yml
    - |— e2e-tests.yml
- |
- |— sql/
  - |— 01\_core\_schema.sql
  - |— 02\_content\_ddl.sql
  - |— 03\_delivery\_ddl.sql
  - |— 04\_analytics\_ddl.sql
  - |— 05\_calibration\_ddl.sql
  - |— 06\_governance\_ddl.sql
  - |— 07\_indexes.sql
  - |— 08\_rls\_policies.sql
  - |— 09\_seed\_data.sql
- |
- |— qbank-backend/
  - |— requirements.txt
  - |— requirements-dev.txt
  - |— pytest.ini
  - |— .env.example
  - |— alembic.ini
  - |— app/
    - |— \_\_init\_\_.py
    - |— main.py
    - |— core/
      - |— config.py
      - |— database.py
      - |— cache.py
      - |— events.py
      - |— auth.py
      - |— security.py
      - |— telemetry.py
      - |— exceptions.py
    - |— models/
      - |— orm.py
      - |— schemas.py
      - |— events.py

```
| | | └── analytics.py
| | | └── api/
| | | └── auth.py
| | | └── quizzes.py
| | | └── author.py
| | | └── admin.py
| | | └── analytics.py
| | | └── calibration.py
| | | └── reports.py
| | | └── webhooks.py
| | └── services/
| | | └── adaptive.py
| | | └── calibration.py
| | | └── recommender.py
| | | └── selector.py
| | | └── analytics.py
| | | └── search.py
| | | └── export.py
| | └── jobs/
| | | └── worker.py
| | | └── queue.py
| | | └── calibration_job.py
| | | └── analytics_job.py
| | | └── export_job.py
| | └── migrations/
| | └── versions/
| └── analytics/
| | └── calibration/
| | | └── sh_core.py
| | | └── sh_iterative.py
| | | └── irt_2pl.py
| | | └── irt_3pl.py
| | | └── ctt_metrics.py
| | └── ml/
| | | └── embeddings.py
| | | └── difficulty_predictor.py
| | | └── recommender_model.py
| └── tests/
| | └── conftest.py
| | └── test_api/
| | └── test_services/
| | └── test_analytics/
|
└── admin-ui/
```

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| ├── package.json
| ├── next.config.js
| ├── tsconfig.json
| ├── tailwind.config.js
| ├── components/
| | ├── layout/
| | ├── charts/
| | ├── tables/
| | └── forms/
| ├── pages/
| | ├── index.tsx
| | ├── login.tsx
| | ├── dashboard.tsx
| | ├── questions/
| | ├── calibration/
| | ├── analytics/
| | ├── reports/
| | └── settings/
| ├── lib/
| | ├── api.ts
| | ├── auth.ts
| | └── utils.ts
| └── styles/
|     └── globals.css
|
| ├── streaming/
| | ├── kafka/
| | └── event-schemas/
| ├── flink/
| | └── jobs/
| ├── clickhouse/
| | └── schemas/
|
| ├── ml-services/
| | ├── irt-service/
| | ├── recommender-service/
| | └── difficulty-service/
|
| ├── scripts/
| ├── setup.sh
| ├── migrate.sh
| ├── seed.sh
| └── backup.sh
|
```

```
└─ docs/
   └─ architecture.md
   └─ api-docs.md
   └─ deployment.md
   └─ development.md
```

## Key Features

### 1. Content Management

- **Multi-version question system** with Git-like versioning
- **Rich media support** (images, videos, LaTeX, tables)
- **Blueprint alignment** with exam specifications
- **Collaborative authoring workflow** with review states
- **Bulk import/export** (QTI, GIFT, CSV formats)

### 2. Adaptive Testing Engine

- **IRT Models:** 2PL, 3PL calibration with Stan/PyMC
- **Sympson-Hetter exposure control** with iterative calibration
- **Real-time  $\theta$  estimation** using EAP/MLE
- **Blueprint-aware selection** with coverage constraints
- **Multi-dimensional IRT** for topic-specific abilities

### 3. Analytics & Reporting

- **Real-time dashboards** with WebSocket updates
- **Item health monitoring** (drift detection, DIF analysis)
- **Cohort analysis** with demographic breakdowns
- **Performance predictions** using ML models
- **Custom report generation** with scheduled delivery

### 4. Enterprise Features

- **Multi-tenancy** with row-level security
- **RBAC** with fine-grained permissions
- **Audit logging** for compliance
- **SSO integration** (SAML, OAuth2, OIDC)

- **API rate limiting** and usage quotas

## 5. Technical Excellence

- **Event streaming** with Kafka for real-time analytics
- **Distributed caching** with Redis Cluster
- **Search** with Elasticsearch for content discovery
- **Observability** with OpenTelemetry
- **CI/CD** with GitHub Actions and ArgoCD

## Technology Stack

### Backend

- **FastAPI** (Python 3.11+) - High-performance async API
- **PostgreSQL 15+** - Primary database with pgvector, pg\_partman
- **Redis 7+** - Caching and session management
- **Apache Kafka** - Event streaming
- **ClickHouse** - OLAP for analytics
- **Elasticsearch 8+** - Full-text and semantic search

### Frontend

- **Next.js 14** - React framework with App Router
- **TypeScript** - Type safety
- **Tailwind CSS** - Utility-first styling
- **Recharts/D3.js** - Data visualization
- **React Query** - Data fetching and caching

### ML/Analytics

- **PyTorch/JAX** - Deep learning models
- **Stan/PyMC** - Bayesian IRT calibration
- **Apache Flink** - Stream processing
- **dbt** - Analytics engineering
- **Apache Superset** - BI dashboards

### Infrastructure

- **Docker/Kubernetes** - Container orchestration
- **Terraform** - Infrastructure as code
- **Prometheus/Grafana** - Monitoring
- **Jaeger** - Distributed tracing
- **MinIO** - Object storage for media