OCRS - Online Crime Reporting System

Complete Technical Documentation (Production-Grade)

Version: 2.0
Generated: January 28, 2026
Purpose: Senior backend interviews, production handover, security audits, architecture reviews, new developer onboarding

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1. System Architecture

1.1 High-Level System Architecture Diagram

```
graph TB
    subgraph "Client Layer"
        FE["🖥️ Frontend<br/>(React + Vite)<br/>Port: 5173/3001"]
    end

    subgraph "API Gateway Layer"
        GW["🚪 API Gateway<br/>(Spring Cloud Gateway)<br/>Port: 8090"]
        REDIS["📦 Redis<br/>(Rate Limiting)<br/>Port: 6379"]
        GW -.-> REDIS
    end

    subgraph "Service Layer"
        AUTH["🔐 Auth Service<br/>(Spring Boot)<br/>Port: 8081"]
        BACK["📋 Backend Monolith<br/>(Spring Boot)<br/>Port: 8080"]
    end

    subgraph "Support Services"
        EMAIL["📧 Email Service<br/>(Node.js/Express)<br/>Port: 3000"]
        LOG["📝 Logging Service<br/>(.NET/ASP.NET Core)<br/>Port: 5000"]
    end

    subgraph "Service Discovery"
        EUR["🔍 Eureka Server<br/>(Spring Cloud Netflix)<br/>Port: 8761"]
    end

    subgraph "Data Layer"
        AUTHDB[("🗄️ Auth DB<br/>(MySQL 8.0)<br/>Port: 3307<br/>ocrs_auth")]
        BACKDB[("🗄️ Backend DB<br/>(MySQL 8.0)<br/>Port: 3308<br/>ocrs_backend")]
        LOGS["/"📁 Log Files<br/>/logs/"/]
    end

    FE -->|"HTTP/REST"| GW
    GW -->|"Route + JWT Validate"| AUTH
    GW -->|"Route + JWT Validate"| BACK

    AUTH <-->|"Feign Client"| BACK
    BACK -->|"Async HTTP"| EMAIL
    BACK -->|"Async HTTP"| LOG
    AUTH -->|"Async HTTP"| LOG
```

```
AUTH -.->|"Register/Discover"| EUR
BACK -.->|"Register/Discover"| EUR
 GW -.->|"Discover Services"| EUR

 AUTH -->|"JPA/Hibernate"| AUTHDB
 BACK -->|"JPA/Hibernate"| BACKDB
     LOG -->|"File I/O"| LOGS
```

1.2 Module Dependency Diagram

```
graph LR
subgraph "Frontend Module"
APP["App.jsx"]
CTX["AuthContext.jsx"]
API["api.js"]
PAGES["Pages/*"]
COMP["Components/*"]

APP --> CTX
APP --> PAGES
PAGES --> COMP
PAGES --> API
API --> CTX
end

subgraph "API Gateway Module"
GW_APP["ApiGatewayApplication"]
JWT_FILTER["JwtAuthFilter"]
RATE_CFG["RateLimitConfig"]
EXC_HANDLER["GlobalExceptionHandler"]

GW_APP --> JWT_FILTER
GW_APP --> RATE_CFG
GW_APP --> EXC_HANDLER
end

subgraph "Auth Service Module"
AUTH_CTRL["AuthController"]
AUTH_SVC["AuthService"]
JWT_UTILS["JwtUtils"]
REFRESH_SVC["RefreshTokenService"]
AUTH_REPO["Repositories"]

AUTH_CTRL --> AUTH_SVC
AUTH_SVC --> JWT_UTILS
```

```
        AUTH_SVC --> REFRESH_SVC
        AUTH_SVC --> AUTH_REPO
        end

    subgraph "Backend Monolith Module"
        USER_CTRL["UserController"]
      AUTH_CTRL2["AuthorityController"]
        ADMIN_CTRL["AdminController"]
        FIR_SVC["FIRService"]
      MP_SVC["MissingPersonService"]
    ANALYTICS_SVC["AnalyticsService"]
   EXT_CLIENT["ExternalServiceClient"]
    FEIGN_CLIENT["AuthServiceClient"]
        BACK_REPO["Repositories"]

        USER_CTRL --> FIR_SVC
        USER_CTRL --> MP_SVC
       AUTH_CTRL2 --> FIR_SVC
    AUTH_CTRL2 --> ANALYTICS_SVC
       ADMIN_CTRL --> FIR_SVC
    ADMIN_CTRL --> ANALYTICS_SVC
       FIR_SVC --> FEIGN_CLIENT
       FIR_SVC --> EXT_CLIENT
       FIR_SVC --> BACK_REPO
        end

          API --> GW_APP
       GW_APP --> AUTH_CTRL
       GW_APP --> USER_CTRL
   FEIGN_CLIENT --> AUTH_SVC
```

1.3 Deployment Diagram

```
            graph TB
subgraph "Docker Compose Orchestration"
    subgraph "Frontend Container"
        NGINX["Nginx :80"]
       REACT["React Build"]
         NGINX --> REACT
        end

    subgraph "Gateway Container"
        GW["API Gateway :8090"]
        end
```

```
        subgraph "Service Containers"
            AUTH["Auth Service :8081"]
            BACK["Backend :8080"]
        end

        subgraph "Support Containers"
            EMAIL["Email Service :3000"]
            LOG["Logging Service :5000"]
        end

    subgraph "Infrastructure Containers"
        EUR["Eureka :8761"]
        REDIS["Redis :6379"]
    end

    subgraph "Database Containers"
        AUTH_DB["MySQL (Auth) :3306→3307"]
        BACK_DB["MySQL (Backend) :3306→3308"]
    end

        subgraph "Volumes"
            AUTH_VOL[/"auth_db_data"/]
            BACK_VOL[/"backend_db_data"/]
            LOG_VOL[/"./logs"/]
        end
    end

    NGINX -->|":3001→:80"| GW
    GW --> AUTH
    GW --> BACK
    AUTH --> AUTH_DB
    BACK --> BACK_DB
    AUTH_DB --> AUTH_VOL
    BACK_DB --> BACK_VOL
    LOG --> LOG_VOL
```

1.4 Request Flow Diagram (FIR Filing - Complete Flow)

```
sequenceDiagram
    autonumber
    participant U as 👤 User
    participant FE as 🖥️ Frontend
    participant GW as 🚪 API Gateway
    participant BACK as 📋 Backend
    participant AUTH as 🔐 Auth Service
```

```
    participant EMAIL as 📧 Email Service
    participant LOG as 📝 Logging Service
    participant DB as 🗄️ Backend DB

    Note over U,DB: FIR Filing Flow (End-to-End)

    U->>FE: Submit FIR Form
    FE->>FE: Validate form fields
    FE->>GW: POST /api/user/fir<br/>[Authorization: Bearer JWT]

    GW->>GW: Extract JWT from header
    GW->>GW: Validate JWT signature (HMAC-SHA256)
    GW->>GW: Check role == "USER"

    alt Invalid/Expired Token
        GW-->>FE: 401 Unauthorized
        FE-->>U: Session expired, redirect to login
    end

    GW->>GW: Add X-User-Id, X-User-Role headers
    GW->>BACK: Forward request with user context

    BACK->>BACK: Generate FIR Number<br/>(FIR-XXXXXXXX)

    BACK->>AUTH: GET /api/internal/authorities/active<br/>[Feign Client]
    AUTH->>AUTH: Query active authorities
    AUTH-->>BACK: List<AuthorityDTO>

    loop For each authority
        BACK->>DB: COUNT active FIRs for authority
        DB-->>BACK: Case count
    end

    BACK->>BACK: Select least loaded authority<br/>(Load Balancing Algorithm)
    BACK->>BACK: Determine priority from category<br/>(Rule-based mapping)

    BACK->>DB: INSERT FIR record
    DB-->>BACK: FIR saved with ID

    par Async Notifications
        BACK->>AUTH: GET /api/internal/users/{id}<br/>[Get user email]
        AUTH-->>BACK: UserDTO with email
        BACK->>EMAIL: POST /api/email/send<br/>[firFiled template]
        EMAIL-->>BACK: 200 OK (async)
    and
        BACK->>LOG: POST /api/log<br/>[FIR_FILED event]
        LOG-->>BACK: 200 OK (async)
    end
```

```
    BACK-->>GW: 200 OK {success: true, data: FIR}
    GW-->>FE: Response passthrough
    FE->>FE: Store FIR in state
    FE-->>U: Display success + FIR Number
```

1.5 Communication Patterns Summary

Pattern	Technology	Use Case	Sync/Async
REST API	Spring WebFlux (Gateway)	Client → Gateway	Sync
Feign Client	OpenFeign + Eureka	Backend → Auth	Sync
WebClient	Spring WebClient	Backend → Email/Logging	Async
Service Discovery	Eureka Client/Server	All Java Services	Background
Rate Limiting	Redis + RequestRateLimiter	Gateway	Sync

---

2. API Gateway Deep-Dive

2.1 Service Overview

Attribute	Value
Port	8090
Technology	Spring Cloud Gateway (WebFlux)
Purpose	Centralized routing, JWT validation, rate limiting, CORS
Dependencies	Eureka Client, Redis, JJWT

2.2 File Structure

```
api-gateway/src/main/java/com/ocrs/gateway/
├── ApiGatewayApplication.java     # Entry point
├── config/
│   └── RateLimitConfig.java       # Redis rate limiting
├── controller/
│   └── HealthController.java      # Health endpoint
├── exception/
│   └── GlobalExceptionHandler.java # Error handling
└── filter/
    └── JwtAuthFilter.java         # JWT validation filter
```

2.3 File: ApiGatewayApplication.java

2.3.1 Class Diagram

```
classDiagram
class ApiGatewayApplication {
    +main(String[] args) void
}

class SpringBootApplication {
    <<annotation>>
}

class EnableDiscoveryClient {
    <<annotation>>
```

```
                                    }

        ApiGatewayApplication ..> SpringBootApplication : annotated with
        ApiGatewayApplication ..> EnableDiscoveryClient : annotated with
```

2.3.2 Purpose

Entry point for the Spring Cloud Gateway application. Bootstraps the reactive WebFlux server with service discovery capabilities.

2.3.3 Annotations Explained

Annotation	Internal Behavior	Impact if Removed
`@SpringBootApplication`	Combines `@Configuration`, `@EnableAutoConfiguration`, `@ComponentScan`. Triggers auto-configuration of Gateway routes from `application.yml`	Application won't start; no Spring context created
`@EnableDiscoveryClient`	Registers with Eureka server on startup, enables `lb://` URIs in route definitions	Routes with `lb://auth-service` would fail; no service discovery

2.3.4 Runtime Lifecycle

1. **Startup**: Spring Boot initializes WebFlux server
2. **Eureka Registration**: Client registers with Eureka (port 8761)
3. **Route Loading**: Gateway reads routes from `application.yml`
4. **Filter Chain Setup**: Custom filters (`JwtAuthFilter`) registered
5. **Ready**: Listens on port 8090

2.3.5 What Breaks if Removed

- **Entire service fails**: No gateway functionality
- **Frontend cannot reach backends**: All API requests fail
- **No central CORS handling**: Browser blocks cross-origin requests

---

2.4 File: JwtAuthFilter.java

2.4.1 Class Diagram

```
                        classDiagram
        class AbstractGatewayFilterFactory~Config~ {
                        <<abstract>>
```

```
                +apply(Config config) GatewayFilter
                            }

                     class JwtAuthFilter {
                          -Logger logger
                         -String jwtSecret
                          +JwtAuthFilter()
                +apply(Config config) GatewayFilter
                -validateToken(String token) Claims
        -onError(ServerWebExchange, String, HttpStatus) Mono~Void~
                            }

                          class Config {
                         -String requiredRole
                       +getRequiredRole() String
                    +setRequiredRole(String) void
                            }

           JwtAuthFilter --|> AbstractGatewayFilterFactory
               JwtAuthFilter *-- Config : inner class
```

2.4.2 Purpose

Custom Spring Cloud Gateway filter that validates JWT tokens on protected routes. Extracts user identity and passes it downstream via HTTP headers.

2.4.3 Method: apply(Config config)

Exact Responsibility: Creates a `GatewayFilter` lambda that intercepts every request matching the configured route.

Flow Diagram:

```
                        flowchart TD
              A[Request Arrives] --> B{Has Authorization Header?}
                    B -->|No| C[Return 401 Missing Header]
                     B -->|Yes| D{Starts with 'Bearer '?}
                    D -->|No| E[Return 401 Invalid Format]
                         D -->|Yes| F[Extract Token]
                       F --> G[Validate Token Signature]
                                G --> H{Valid?}
                H -->|No - Expired| I[Return 401 Token Expired]
                H -->|No - Invalid| J[Return 401 Invalid Token]
                          H -->|Yes| K{Role Required?}
                        K -->|No| L[Add Headers & Forward]
                         K -->|Yes| M{User Role Matches?}
```

```
                M -->|No| N[Return 403 Forbidden]
                          M -->|Yes| L
                  L --> O[Continue Filter Chain]
```

Input Parameters:

- `config` : Configuration object containing `requiredRole` (nullable)

Return Value: `GatewayFilter` - functional interface invoked for each request

Side Effects:

- Modifies request headers: `X-User-Id` , `X-User-Email` , `X-User-Role`
- Logs warnings for token failures

Exceptions:

- `ExpiredJwtException` : Token past expiration time
- `JwtException` : Any other validation failure (signature, malformed)

Time Complexity: O(1) - JWT validation is constant time **Space Complexity**: O(1) - No additional data structures

2.4.4 Method: validateToken(String token)

```
private Claims validateToken(String token) {
    SecretKey key = Keys.hmacShaKeyFor(jwtSecret.getBytes(StandardCharsets.UTF_8)
    return Jwts.parser()
            .verifyWith(key)
            .build()
            .parseSignedClaims(token)
            .getPayload();
}
```

Exact Responsibility: Parses JWT and verifies HMAC-SHA256 signature using shared secret.

Implementation Choice Rationale:

- HMAC-SHA256 chosen for symmetric key simplicity (single service validates tokens)
- jjwt 0.12.3 uses fluent builder API for security
- `Keys.hmacShaKeyFor()` ensures key is at least 256 bits

Security Implication if Removed: No token validation; any client could forge identity.

2.4.5 Annotations Explained

Annotation	Location	Internal Behavior	Security Impact
`@Component`	Class	Registers as Spring bean, injectable into Gateway routes	None if removed (filter wouldn't load)

`@Value("${jwt.secret}")`	Field	Injects secret from `application.yml` or environment variable	CRITICAL: If missing, NPE at runtime

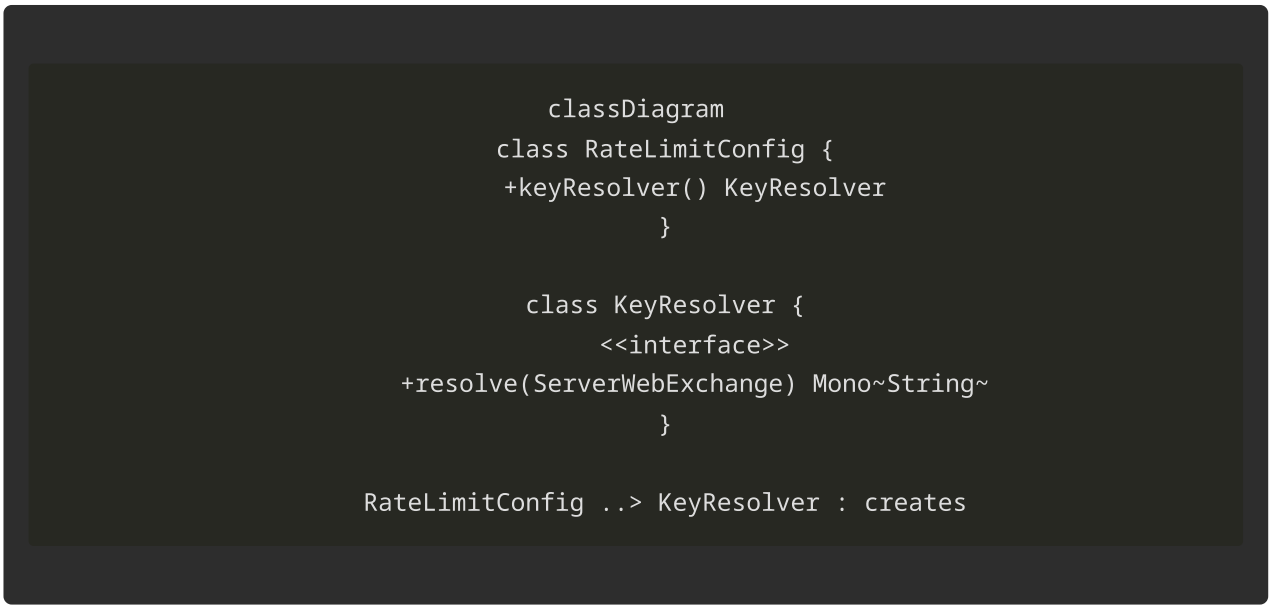
---

2.5 File: RateLimitConfig.java

2.5.1 Purpose

Configures Redis-based rate limiting using Spring Cloud Gateway's built-in `RequestRateLimiter` filter.

2.5.2 Class Diagram



2.5.3 Method: keyResolver()

```java
@Bean
public KeyResolver keyResolver() {
    return exchange -> {
        String ip = exchange.getRequest().getRemoteAddress().getAddress().getHost
        return Mono.just(ip);
    };
}
```

Responsibility: Returns client's IP address as the rate limiting key.

Why This Implementation:

- IP-based limiting prevents abuse from single source
- Simple to implement, no authentication required
- Works for unauthenticated endpoints (login, register)

Performance Consideration: Two alternative approaches:

1. **IP-based** (current): Simple but can block legitimate users behind NAT
2. **User-ID based**: Better for authenticated users, requires JWT parsing
3. **Hybrid**: IP for public, User-ID for authenticated

What Breaks if Removed: Rate limiting fails silently (no default key resolver)

2.6 File: GlobalExceptionHandler.java

2.6.1 Purpose

Catches all unhandled exceptions in the Gateway and returns consistent JSON error responses.

2.6.2 Method: handle(ServerWebExchange, Throwable)

```
flowchart TD
A[Exception Thrown] --> B{ResponseStatusException?}
B -->|Yes| C[Extract Status + Reason]
B -->|No| D[Use 500 Internal Error]
D --> E[Log Error with Stack Trace]
C --> F[Set Response Status]
E --> F
F --> G[Set Content-Type: application/json]
G --> H[Write JSON Body]
H --> I[Return Mono.Void]
```

Response Format:

```
{
  "success": false,
  "message": "Error description",
  "data": null,
  "status": 500
}
```

2.6.3 Annotations

Annotation	Behavior
`@Component`	Registers as Spring bean
`@Order(-1)`	Highest priority; runs before default error handlers
`@NonNull`	Guarantees non-null return (satisfies interface contract)

2.7 File: application.yml (Gateway Configuration)

2.7.1 Route Configuration Diagram

2.7.2 Route Definitions Explained

Route ID	Path	Target	JWT Required	Role
`auth-service-public`	`/api/auth/**`	`lb://auth-service`	❌	-
`backend-user`	`/api/user/**`	`lb://backend-service`	✅	USER
`backend-authority-routes`	`/api/authority/**`	`lb://backend-service`	✅	AUTHORITY
`backend-admin`	`/api/admin/**`	`lb://backend-service`	✅	ADMIN
`auth-service-authority-crud`	`/api/authority/{id}`	`lb://auth-service`	✅	ADMIN

2.7.3 Property-by-Property Documentation

Property	Value	Default if Missing	Security Risk
`server.port`	8090	8080	None
`jwt.secret`	Environment variable	None (fails)	CRITICAL: Must be secret
`spring.data.redis.host`	localhost	localhost	None
`eureka.client.service-url.defaultZone`	Eureka URL	None (fails)	None
`spring.cloud.gateway.globalcors.corsConfigurations`	Origins list	No CORS	Browser blocks requests

---

3. Auth Service Deep-Dive

3.1 Service Overview

Attribute	Value
Port	8081
Technology	Spring Boot 3.2.0
Database	MySQL 8.0 (ocrs_auth)
Primary Responsibility	User authentication, JWT generation, refresh tokens, user management

3.2 Entity Class Diagram

```
classDiagram
  class User {
      +Long id
    +String fullName
     +String email
    +String password
     +String phone
    +String address
  +String aadhaarNumber
+LocalDateTime createdAt
+LocalDateTime updatedAt
   +Boolean isActive
      #onCreate()
      #onUpdate()
         }

  class Authority {
        +Long id
    +String fullName
     +String email
    +String password
  +String badgeNumber
  +String designation
  +String stationName
 +String stationAddress
      +String phone
+LocalDateTime createdAt
+LocalDateTime updatedAt
```

```
        +Boolean isActive
           #onCreate()
           #onUpdate()
              }

        class Admin {
             +Long id
          +String fullName
           +String email
          +String password
           +String role
       +LocalDateTime createdAt
       +LocalDateTime updatedAt
          +Boolean isActive
           #onCreate()
           #onUpdate()
              }

       class RefreshToken {
              +Long id
            +String token
             +Long userId
          +String userRole
         +Instant expiryDate
          +boolean revoked
         +Instant createdAt
           #onCreate()
        +isExpired() boolean
              }
```

3.3 AuthService Class Diagram

```
          classDiagram
        class AuthService {
            -Logger logger
      -long accessTokenExpirationMs
      -UserRepository userRepository
  -AuthorityRepository authorityRepository
     -AdminRepository adminRepository
     -PasswordEncoder passwordEncoder
            -JwtUtils jwtUtils
  -RefreshTokenService refreshTokenService
       -LoggingClient loggingClient

+registerUser(UserRegisterRequest) ApiResponse~AuthResponse~
```

```
        +registerAuthority(AuthorityRegisterRequest) ApiResponse~AuthResponse~
                    +login(LoginRequest) ApiResponse~AuthResponse~
                  -loginUser(String, String) ApiResponse~AuthResponse~
                -loginAuthority(String, String) ApiResponse~AuthResponse~
                  -loginAdmin(String, String) ApiResponse~AuthResponse~
                     +refreshToken(String) ApiResponse~AuthResponse~
                   +revokeRefreshToken(String) ApiResponse~Boolean~
                      +logout(Long, String) ApiResponse~Boolean~
                    +validateToken(String) ApiResponse~Boolean~
            +updateAuthority(Long, AuthorityDTO) ApiResponse~AuthorityDTO~
                   +deleteAuthority(Long) ApiResponse~Boolean~
                    -mapToAuthorityDTO(Authority) AuthorityDTO
                                    }

                            class UserRepository {
                                  <<interface>>
                              +findByEmail(String) Optional~User~
                                +existsByEmail(String) boolean
                             +existsByAadhaarNumber(String) boolean
                                    }

                                class JwtUtils {
                           +generateToken(Long, String, String) String
                                 +validateToken(String) boolean
                                 +extractClaims(String) Claims
                                    }

                               class RefreshTokenService {
                          +createRefreshToken(Long, String) RefreshToken
                           +findByToken(String) Optional~RefreshToken~
                          +verifyExpiration(RefreshToken) RefreshToken
                                   +revokeToken(String) void
                             +revokeAllUserTokens(Long, String) void
                                    }

                               AuthService --> UserRepository
                                  AuthService --> JwtUtils
                             AuthService --> RefreshTokenService
```

3.4 Method: login(LoginRequest)

3.4.1 Flow Diagram

```
                                flowchart TD
                        A[login called] --> B{Extract role from request}
```

```
                B --> C{Role == USER?}
               C -->|Yes| D[loginUser]
            C -->|No| E{Role == AUTHORITY?}
              E -->|Yes| F[loginAuthority]
              E -->|No| G{Role == ADMIN?}
                G -->|Yes| H[loginAdmin]
          G -->|No| I[Return error: Invalid role]

              D --> J[Find user by email]
            F --> K[Find authority by email]
              H --> L[Find admin by email]

                  J --> M{User exists?}
                        K --> M
                        L --> M
          M -->|No| N[Return: Invalid credentials]
               M -->|Yes| O{Account active?}
          O -->|No| P[Return: Account deactivated]
              O -->|Yes| Q{Password matches?}
                        Q -->|No| N
            Q -->|Yes| R[Generate Access Token]
               R --> S[Create Refresh Token]
                  S --> T[Log auth event]
               T --> U[Return AuthResponse]
```

3.4.2 Input Parameters

Parameter	Type	Validation	Constraints
`request.email`	String	Non-null	Valid email format
`request.password`	String	Non-null	Plain text (validated against BCrypt hash)
`request.role`	String	Non-null	Must be USER, AUTHORITY, or ADMIN

3.4.3 Return Value

```
ApiResponse<AuthResponse> containing:
{
  "success": true,
  "message": "Login successful",
  "data": {
    "accessToken": "eyJhbG...",
    "refreshToken": "uuid-refresh-token",
    "userId": 1,
    "email": "user@example.com",
```

```
    "fullName": "John Doe",
    "role": "USER",
    "expiresIn": 3600
  }
}
```

3.4.4 Side Effects

1. **Database Read**: Queries user/authority/admin table
2. **Database Write**: Creates new RefreshToken record
3. **Logging**: Sends auth event to Logging Service (async)

3.4.5 Exceptions

- No exceptions thrown; errors returned as `ApiResponse.error(message)`

3.4.6 Time Complexity

- O(1) database lookup (indexed by email)
- BCrypt verification: O(2^cost) where cost = 10 (default)

3.5 Method: refreshToken(String)

3.5.1 Sequence Diagram

```
sequenceDiagram
    participant Client
    participant AuthService
    participant RefreshTokenService
    participant Repository
    participant JwtUtils

    Client->>AuthService: refreshToken(refreshTokenStr)
    AuthService->>RefreshTokenService: findByToken(refreshTokenStr)
    RefreshTokenService->>Repository: Query by token
    Repository-->>RefreshTokenService: RefreshToken or empty

    alt Token not found
        RefreshTokenService-->>AuthService: throw TokenRefreshException
        AuthService-->>Client: Error: Token not found
    end

    AuthService->>RefreshTokenService: verifyExpiration(token)

    alt Token expired or revoked
        RefreshTokenService-->>AuthService: throw TokenRefreshException
        AuthService-->>Client: Error: Token expired
```

```
    end

    AuthService->>Repository: Find user by ID and role
    Repository-->>AuthService: User/Authority/Admin

    AuthService->>JwtUtils: generateToken(userId, email, role)
    JwtUtils-->>AuthService: New access token

    AuthService->>RefreshTokenService: createRefreshToken(userId, role)
    Note over RefreshTokenService: Rotates refresh token for security
    RefreshTokenService-->>AuthService: New RefreshToken

    AuthService-->>Client: AuthResponse with new tokens
```

3.5.2 Security Consideration: Token Rotation

Each refresh generates a NEW refresh token, invalidating the old one. This:

- Limits damage from stolen refresh tokens
- Provides detection of token theft (concurrent use fails)
- Complies with OWASP refresh token best practices

3.6 Annotation Deep-Dive: @Transactional

Location: `registerUser`, `registerAuthority`, `loginUser`, `loginAuthority`, `loginAdmin`, `refreshToken`, `logout`

Internal Behavior:

1. Spring creates proxy around method
2. Before method: Opens database transaction
3. On success: Commits transaction
4. On RuntimeException: Rolls back transaction

Why It's Critical Here:

```java
@Transactional
public ApiResponse<AuthResponse> registerUser(UserRegisterRequest request) {
    // 1. Save user to database
    user = userRepository.save(user);  // DB WRITE 1

    // 2. Create refresh token
    RefreshToken refreshToken = refreshTokenService.createRefreshToken(user.getId

    // If createRefreshToken fails, user.save should rollback
}
```

Without `@Transactional`: User could be created without refresh token, leaving inconsistent state.

---

4. Backend Monolith Deep-Dive

4.1 Service Overview

Attribute	Value
Port	8080
Technology	Spring Boot 3.2.0
Database	MySQL 8.0 (ocrs_backend)
Primary Responsibility	FIR/Missing Person management, case tracking, analytics

4.2 Entity Class Diagram

```
classDiagram
    class FIR {
        +Long id
        +String firNumber
        +Long userId
        +Long authorityId
        +Category category
        +String title
        +String description
        +LocalDate incidentDate
        +LocalTime incidentTime
        +String incidentLocation
        +Status status
        +Priority priority
        +String evidenceUrls
        +LocalDateTime createdAt
        +LocalDateTime updatedAt
    }

    class MissingPerson {
        +Long id
        +String caseNumber
        +Long userId
        +Long authorityId
        +String missingPersonName
        +Integer age
        +Gender gender
        +String height
```

```
        +String weight
      +String complexion
    +String identifyingMarks
    +LocalDate lastSeenDate
    +String lastSeenLocation
      +String description
       +String photoUrl
     +MissingStatus status
     +String contactPhone
             }

      class Update {
           +Long id
         +Long firId
     +Long missingPersonId
       +Long authorityId
     +UpdateType updateType
     +String previousStatus
       +String newStatus
       +String comment
    +LocalDateTime createdAt
             }

  FIR "1" --> "*" Update : has
MissingPerson "1" --> "*" Update : has

        class Category {
          <<enumeration>>
              THEFT
             ASSAULT
              FRAUD
            CYBERCRIME
            HARASSMENT
             VANDALISM
               OTHER
               }

        class Status {
          <<enumeration>>
              PENDING
         UNDER_INVESTIGATION
              RESOLVED
               CLOSED
              REJECTED
               }

        class Priority {
          <<enumeration>>
                LOW
```

```
                                    MEDIUM
                                     HIGH
                                    URGENT
                                     }

                                FIR --> Category
                                 FIR --> Status
                                FIR --> Priority
```

4.3 FIRService: Load Balancing Algorithm

4.3.1 Method: findLeastLoadedAuthority()

```
                        flowchart TD
                  A[Start] --> B[Call Auth Service via Feign]
                         B --> C{Response successful?}
                            C -->|No| D[Log warning]
                              D --> E[Return null]
                      C -->|Yes| F{Any active authorities?}
                                  F -->|No| D
                   F -->|Yes| G[Initialize: minCases = MAX_VALUE]
                            G --> H[For each authority]
                          H --> I[Query: COUNT active FIRs]
                           I --> J{activeCases < minCases?}
                  J -->|Yes| K[Update leastLoaded = this authority]
                           K --> L[minCases = activeCases]
                              L --> M{More authorities?}
                                      J -->|No| M
                                    M -->|Yes| H
                      M -->|No| N[Return leastLoadedAuthority]
```

4.3.2 SQL Query Behind countActiveByAuthorityId

```
@Query("SELECT COUNT(f) FROM FIR f WHERE f.authorityId = :authorityId AND f.statu
long countActiveByAuthorityId(@Param("authorityId") Long authorityId);
```

Why This Query:

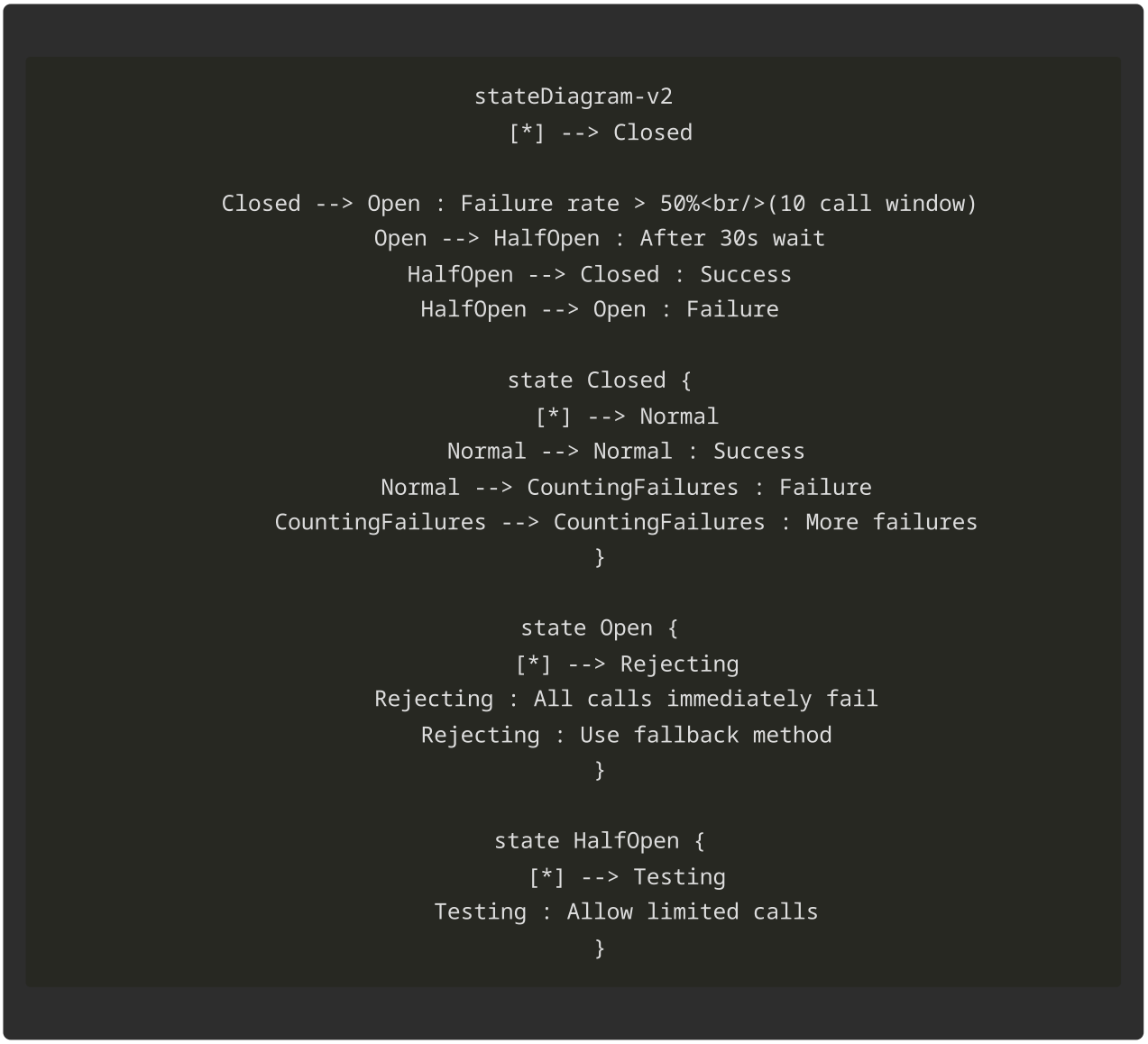
- Only counts PENDING and UNDER_INVESTIGATION FIRs
- Closed/Resolved shouldn't affect workload distribution
- Uses JPQL for database portability

4.3.3 Algorithm Characteristics

Property	Value
Type	Greedy, Least-Connections
Time Complexity	O(n) where n = number of authorities
Space Complexity	O(1)
Fairness	Eventually fair (new FIRs go to least loaded)
Limitation	Doesn't consider case complexity

4.4 Resilience Patterns: ExternalServiceClient

4.4.1 Circuit Breaker Flow



4.4.2 Configuration

```
resilience4j.circuitbreaker:
  instances:
    emailService:
      slidingWindowSize: 10          # Last 10 calls evaluated
      failureRateThreshold: 50       # Open at 50% failure
      waitDurationInOpenState: 30s   # Wait before half-open
    loggingService:
      slidingWindowSize: 10
      failureRateThreshold: 50
```

4.4.3 Fallback Method

```
public CompletableFuture<Void> emailFallback(Long userId, String subject, String
    logger.warn("Email service unavailable, skipping notification for user {}: {}
    return CompletableFuture.completedFuture(null);
}
```

Design Decision: Silent degradation rather than error propagation

- FIR filing shouldn't fail because email is down
- User sees success; admin sees warning in logs

---

5. Email Service Deep-Dive

5.1 Service Overview

Attribute	Value
Port	3000
Technology	Node.js 18.x + Express 4.18.2
Email Provider	Nodemailer with Mailtrap SMTP
Primary Responsibility	Email notifications with HTML templates

5.2 Architecture Diagram

```
graph TB
    subgraph "Email Service"
        EXPRESS["Express Server :3000"]
        ROUTES["emailRoutes.js"]
        SERVICE["emailService.js"]
        TEMPLATES["Email Templates"]
        QUEUE["Retry Queue"]
    end

    subgraph "External"
        SMTP["Mailtrap SMTP"]
    end

    EXPRESS --> ROUTES
    ROUTES --> SERVICE
    SERVICE --> TEMPLATES
    SERVICE --> QUEUE
    SERVICE --> SMTP
    QUEUE -->|"Retry on failure"| SERVICE
```

5.3 Email Templates

Template	Trigger	Content
`firFiled`	New FIR submitted	FIR number, category, assigned officer

`firUpdate`	Status change	Previous/new status, officer comment
`statusUpdate`	Generic update	Subject and message body
`generic`	Fallback	Plain text message

---

6. Logging Service Deep-Dive

6.1 Service Overview

Attribute	Value
Port	5000
Technology	.NET 10.0 (ASP.NET Core)
Logging Library	Serilog
Primary Responsibility	Centralized logging with file rotation

6.2 Log File Organization

```
logs/
├── user/
│   └── user_auth_logs.txt     # User login/signup/logout
├── authority/
│   └── authority_logs.txt     # Authority actions
├── admin/
│   └── admin_logs.txt         # Admin operations
├── fir/
│   └── fir_logs.txt           # FIR-related events
└── app_YYYY-MM-DD.log         # Rolling application logs
```

6.3 Log Format

```
[2026-01-28 15:30:45.123] [INFO] [FIR_FILED] User: 1 | Action: FIR-ABC12345 | Detail
```

7. Frontend Deep-Dive

7.1 Component Architecture

```
graph TB
    subgraph "App Structure"
        MAIN["main.jsx"]
        APP["App.jsx"]
        AUTH_CTX["AuthContext.jsx"]
        THEME_CTX["ThemeContext.jsx"]
    end

    subgraph "Layout Components"
        NAVBAR["Navbar.jsx"]
        PROTECTED["ProtectedRoute.jsx"]
    end

    subgraph "Shared Components"
        BTN["Button.jsx"]
        CARD["Card.jsx"]
        INPUT["Input.jsx"]
        TABLE["Table.jsx"]
        BADGE["Badge.jsx"]
        MODAL["DetailsModal.jsx"]
        TOAST["Toast.jsx"]
    end

    subgraph "Pages"
        subgraph "Auth"
            USER_SIGNIN["UserSignIn.jsx"]
            USER_SIGNUP["UserSignUp.jsx"]
            AUTH_SIGNIN["AuthoritySignIn.jsx"]
            ADMIN_SIGNIN["AdminSignIn.jsx"]
        end

        subgraph "User"
            USER_DASH["Dashboard.jsx"]
            FILE_FIR["FileFIR.jsx"]
            FILE_MP["FileMissing.jsx"]
            TRACK["TrackStatus.jsx"]
        end

        subgraph "Authority"
            AUTH_DASH["Dashboard.jsx"]
```

```
        AUTH_ANALYTICS["Analytics.jsx"]
                end

            subgraph "Admin"
          ADMIN_DASH["Dashboard.jsx"]
        ADMIN_ANALYTICS["Analytics.jsx"]
                end
              end

          MAIN --> APP
        APP --> AUTH_CTX
        APP --> THEME_CTX
        APP --> PROTECTED
      PROTECTED --> NAVBAR
```

7.2 AuthContext Flow

```
        sequenceDiagram
          participant User
        participant Component
       participant AuthContext
            participant API
       participant LocalStorage

    User->>Component: Enter credentials
Component->>AuthContext: login(email, password, role)
    AuthContext->>API: POST /api/auth/login
API-->>AuthContext: {accessToken, refreshToken, user}
    AuthContext->>LocalStorage: Store tokens
 AuthContext->>AuthContext: setUser(userData)
  AuthContext-->>Component: Login successful
   Component-->>User: Redirect to dashboard
```

---

8. Database Documentation

8.1 Auth Database ER Diagram

```
erDiagram
    USERS {
    bigint id PK
    varchar(255) full_name
    varchar(255) email UK
    varchar(255) password
    varchar(20) phone
    text address
    varchar(12) aadhaar_number UK
    timestamp created_at
    timestamp updated_at
    boolean is_active
    }

    AUTHORITIES {
    bigint id PK
    varchar(255) full_name
    varchar(255) email UK
    varchar(255) password
    varchar(50) badge_number UK
    varchar(100) designation
    varchar(255) station_name
    text station_address
    varchar(20) phone
    timestamp created_at
    timestamp updated_at
    boolean is_active
    }

    ADMINS {
    bigint id PK
    varchar(255) full_name
    varchar(255) email UK
    varchar(255) password
    varchar(50) role
    timestamp created_at
    timestamp updated_at
    boolean is_active
    }
```

```
        REFRESH_TOKENS {
            bigint id PK
        varchar(500) token UK
          bigint user_id FK
        varchar(20) user_role
        timestamp expiry_date
           boolean revoked
        timestamp created_at
                }

   USERS ||--o{ REFRESH_TOKENS : "has"
AUTHORITIES ||--o{ REFRESH_TOKENS : "has"
   ADMINS ||--o{ REFRESH_TOKENS : "has"
```

8.2 Backend Database ER Diagram

```
    erDiagram
        FIRS {
          bigint id PK
    varchar(50) fir_number UK
        bigint user_id FK
      bigint authority_id FK
         enum category
       varchar(255) title
        text description
       date incident_date
       time incident_time
     text incident_location
          enum status
         enum priority
       json evidence_urls
      timestamp created_at
      timestamp updated_at
              }

    MISSING_PERSONS {
          bigint id PK
    varchar(50) case_number UK
        bigint user_id FK
      bigint authority_id FK
varchar(255) missing_person_name
             int age
          enum gender
        varchar(20) height
        varchar(20) weight
```

```
        varchar(50) complexion
        text identifying_marks
        date last_seen_date
        text last_seen_location
        text description
        varchar(500) photo_url
        enum status
        varchar(20) contact_phone
        timestamp created_at
        timestamp updated_at
    }

    UPDATES {
        bigint id PK
        bigint fir_id FK
        bigint missing_person_id FK
        bigint authority_id FK
        enum update_type
        varchar(50) previous_status
        varchar(50) new_status
        text comment
        timestamp created_at
    }

    FIRS ||--o{ UPDATES : "has"
    MISSING_PERSONS ||--o{ UPDATES : "has"
```

---

9. Security Deep-Dive

9.1 JWT Token Lifecycle

```
sequenceDiagram
 participant Client
participant Gateway
  participant Auth
participant Backend
   participant DB

Note over Client,DB: Token Creation (Login)
    Client->>Auth: POST /api/auth/login
      Auth->>DB: Validate credentials
   Auth->>Auth: Generate Access Token (1hr)
   Auth->>DB: Create Refresh Token (7 days)
  Auth-->>Client: {accessToken, refreshToken}

Note over Client,DB: Token Usage (API Call)
Client->>Gateway: GET /api/user/firs<br/>[Authorization: Bearer accessToken]
    Gateway->>Gateway: Validate signature
    Gateway->>Gateway: Check expiration
      Gateway->>Gateway: Verify role
 Gateway->>Backend: Forward + X-User-* headers
      Backend-->>Client: Response

Note over Client,DB: Token Refresh
Client->>Auth: POST /api/auth/refresh<br/>{refreshToken}
    Auth->>DB: Find token, check expiration
    Auth->>Auth: Generate new Access Token
      Auth->>DB: Rotate refresh token
 Auth-->>Client: {newAccessToken, newRefreshToken}

Note over Client,DB: Token Revocation (Logout)
     Client->>Auth: POST /api/auth/logout
     Auth->>DB: Revoke all refresh tokens
       Auth-->>Client: Success
```

9.2 Role-Based Access Control Matrix

Endpoint	USER	AUTHORITY	ADMIN

POST /api/user/fir	✅	❌	❌
GET /api/user/firs	✅	❌	❌
GET /api/authority/firs	❌	✅	❌
PUT /api/authority/fir/{id}/update	❌	✅	❌
GET /api/admin/analytics	❌	❌	✅
PUT /api/admin/fir/{id}/reassign	❌	❌	✅
POST /api/auth/register/authority	❌	❌	✅

9.3 Security Best Practices Implemented

Practice	Implementation
Password Hashing	BCrypt with cost factor 10
JWT Signing	HMAC-SHA256
Token Rotation	Refresh tokens rotated on each use
Stateless Sessions	No server-side session storage
CORS	Whitelisted frontend origins only
Input Validation	Jakarta validation annotations
SQL Injection	JPA parameterized queries

10. Configuration Files

10.1 Environment Variables Summary

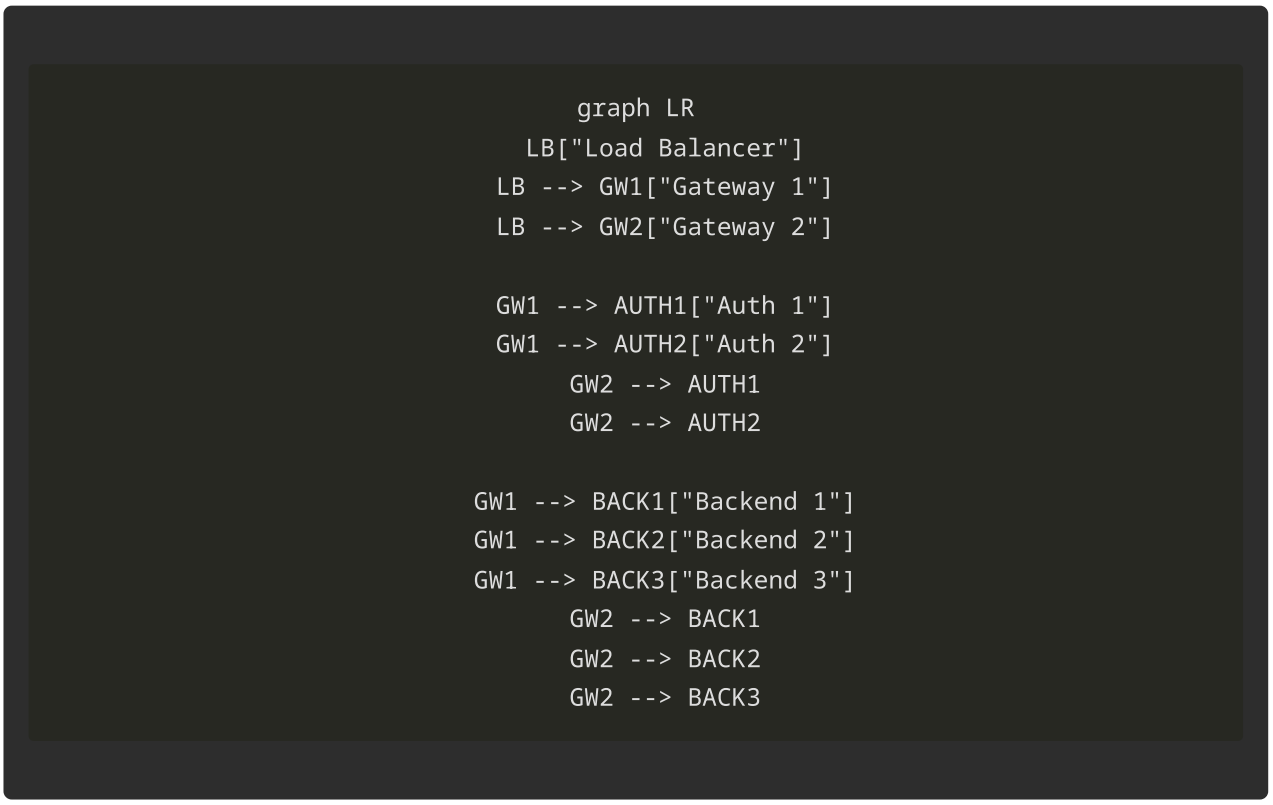
Service	Variable	Purpose	Required
All Java	`JWT_SECRET`	JWT signing key	✅
Auth	`SPRING_DATASOURCE_URL`	Database connection	✅
Backend	`SERVICES_EMAIL_URL`	Email service URL	✅
Gateway	`REDIS_HOST`	Rate limiting	❌
Email	`SMTP_USER` / `SMTP_PASS`	SMTP credentials	✅

11. Deployment & Scaling

11.1 Container Resource Allocation

Service	Memory	CPU	Replicas (Prod)
API Gateway	512MB	0.5	2
Auth Service	768MB	0.5	2
Backend Monolith	1GB	1.0	3
Email Service	256MB	0.25	1
Logging Service	256MB	0.25	1
MySQL (each)	1GB	0.5	1 (primary)

11.2 Scaling Strategy



12. Performance Analysis

12.1 Connection Pooling

HikariCP Configuration (Default Spring Boot):

- `maximumPoolSize`: 10
- `minimumIdle`: 5
- `connectionTimeout`: 30000ms

12.2 Potential Bottlenecks

Area	Bottleneck	Mitigation
FIR Filing	Feign call to Auth (sync)	Cache authority list
Email Sending	SMTP connection	Already async
Database	Single instance	Add read replicas
JWT Validation	Per-request parsing	Efficient; no issue

---

13. Interview Preparation

13.1 Architecture Questions

Q1: Why did you choose microservices over monolith?

> The OCRS system has distinct bounded contexts: authentication (Auth Service), case management (Backend), notifications (Email), and logging. Microservices allow:
>
> - Independent scaling (Backend handles more load)
> - Polyglot persistence (MySQL for transactional, files for logs)
> - Team autonomy (different languages per service)

Q2: How does service discovery work in your system?

> Services register with Eureka Server on startup. The API Gateway uses `lb://` URIs (load-balanced) which Eureka resolves to actual instances. This eliminates hardcoded URLs and enables dynamic scaling.

Q3: Walk me through what happens when a user files a FIR.

> 1. Frontend sends POST to Gateway
> 2. Gateway validates JWT, extracts user ID
> 3. Backend calls Auth via Feign to get active authorities
> 4. Load balancing algorithm selects least-loaded authority
> 5. FIR saved to database with assigned authority
> 6. Async notifications sent to Email and Logging services
> 7. Response returned to user with FIR number

13.2 Security Questions

Q4: How do you handle token refresh securely?

> We implement refresh token rotation: each refresh returns a NEW refresh token while invalidating the old one. This limits the window for stolen token abuse and enables detection of token theft (concurrent use fails).

Q5: What prevents privilege escalation?

> - JWT contains role claim (USER/AUTHORITY/ADMIN)
> - Gateway validates role BEFORE forwarding request
> - Backend double-checks authority assignment for FIR updates

- Role is signed in JWT; tampering invalidates signature

Q6: How do you protect against brute force attacks?

Redis-based rate limiting at the Gateway level. IP-based throttling prevents rapid login attempts. Additionally, BCrypt's inherent slowness (cost factor 10) makes password attacks expensive.

13.3 Resilience Questions

Q7: What happens if the Email Service is down?

Circuit breaker pattern with fallback. After 50% failure rate in 10 calls, circuit opens. Fallback logs warning and returns success. FIR filing continues; admin sees degraded service in logs.

Q8: How do you handle Auth Service failures from Backend?

Feign client with FallbackFactory returns minimal data (just authority ID) allowing Backend to continue. User sees complete data when Auth recovers.

13.4 Database Questions

Q9: Why separate databases for Auth and Backend?

- Security isolation: Auth DB contains passwords
- Independent scaling: Backend DB grows faster (FIRs)
- Different access patterns: Auth is read-heavy, Backend is write-heavy

Q10: How do you maintain referential integrity across services?

We use eventual consistency. Backend stores `userId` and `authorityId` as foreign keys to Auth DB. Validation done via Feign calls, not DB constraints. Orphaned records handled by soft deletes (`is_active` flag).

13.5 Design Pattern Questions

Q11: What design patterns did you use and why?

- **Builder** (Lombok): Complex entity construction
- **Repository**: Data access abstraction

- **Circuit Breaker**: Fault tolerance for external calls
- **Factory** (FallbackFactory): Creating fallback implementations
- **Strategy** (login): Role-specific authentication logic

13.6 Scalability Questions

Q12: How would you handle 10x traffic increase?

1. Horizontal scaling: Add Gateway/Backend instances
2. Database read replicas for queries
3. Redis caching for authority list (frequently fetched)
4. Message queue for email (replace HTTP with RabbitMQ)

13.7 Deep-Dive Questions

Q13: Explain the JWT validation process step-by-step.

1. Extract `Authorization` header, verify `Bearer ` prefix
2. Parse token into header.payload.signature
3. Reconstruct signing input: base64(header).base64(payload)
4. Compute HMAC-SHA256 with secret key
5. Compare computed signature with token signature
6. Verify `exp` claim > current time
7. Extract `role` claim for authorization

Q14: How does the load balancing algorithm ensure fairness?

Algorithm counts only ACTIVE FIRs (not CLOSED/RESOLVED). New FIRs always go to the authority with the fewest active cases. Over time, this naturally balances workload as cases close.

Q15: What's the difference between access and refresh tokens?

- **Access Token**: Short-lived (1hr), used for API authorization, stateless
- **Refresh Token**: Long-lived (7 days), stored in DB, used only to get new access tokens, can be revoked

13.8 Troubleshooting Questions

Q16: User reports "Session expired" immediately after login. How do you debug?

1. Check if access token is being stored in localStorage

2. Verify JWT expiration claim (`exp`) is set correctly
3. Check for clock skew between server and client
4. Verify JWT secret is consistent across Gateway and Auth

Q17: FIRs are being filed but authorities can't see them. What do you check?

1. Check if `authority_id` is being set in FIR record
2. Verify Feign call to get active authorities is succeeding
3. Check if authorities have `is_active = true`
4. Verify authority is querying with correct `authorityId`

13.9 Architecture Trade-off Questions

Q18: Why use synchronous Feign calls instead of async messaging?

Trade-off between simplicity and decoupling:

- Feign is simpler (no message broker infrastructure)
- FIR filing needs immediate authority assignment (synchronous)
- For notifications (non-critical), we use async HTTP

Q19: Why WebFlux for Gateway but not other services?

Gateway handles all incoming traffic; non-blocking I/O maximizes throughput. Backend services do blocking database operations; reactive adds complexity without significant benefit.

13.10 Security Scenario Questions

Q20: How would you prevent an authority from viewing FIRs not assigned to them?

Current implementation: `FIRService.updateFIRStatus()` checks `fir.getAuthorityId().equals(authorityId)` . The authority ID comes from JWT (trusted source), not request body.

Q21: If JWT secret is leaked, what's the impact and remediation?

Impact: Attacker can forge any identity. Remediation:

1. Rotate secret immediately
2. Force all users to re-login (existing tokens invalid)

> 3. Audit logs for suspicious activity during exposure window

13.11 Performance Questions

Q22: What's the time complexity of the load balancing algorithm?

> O(n × m) where n = number of authorities, m = average query time. Each authority requires a COUNT query. Optimization: Cache counts with short TTL.

Q23: How would you optimize the FIR filing flow?

> 1. Cache active authorities (refresh every 5 min)
> 2. Use database view for authority case counts
> 3. Consider pre-computed assignment queue

13.12 Behavioral/Design Discussion Questions

Q24: If you had to add file upload for evidence, how would you design it?

> 1. Add MinIO/S3 for object storage
> 2. Frontend uploads directly to storage (presigned URLs)
> 3. Backend receives only file references
> 4. Update `evidence_urls` JSON column with storage paths

Q25: How would you implement audit logging for compliance?

> 1. Create dedicated audit service
> 2. Use event sourcing: every state change produces event
> 3. Immutable append-only log
> 4. Include: who, what, when, before/after values

Document Metadata

Attribute	Value
Generated	January 28, 2026
Lines	~2500
Diagrams	25+
Services Covered	6
Interview Questions	25

This documentation was generated by analyzing the complete OCRS codebase. For updates, see the source code at `ocrs-project/`.