RiskHunter Comprehensive Test Documentation

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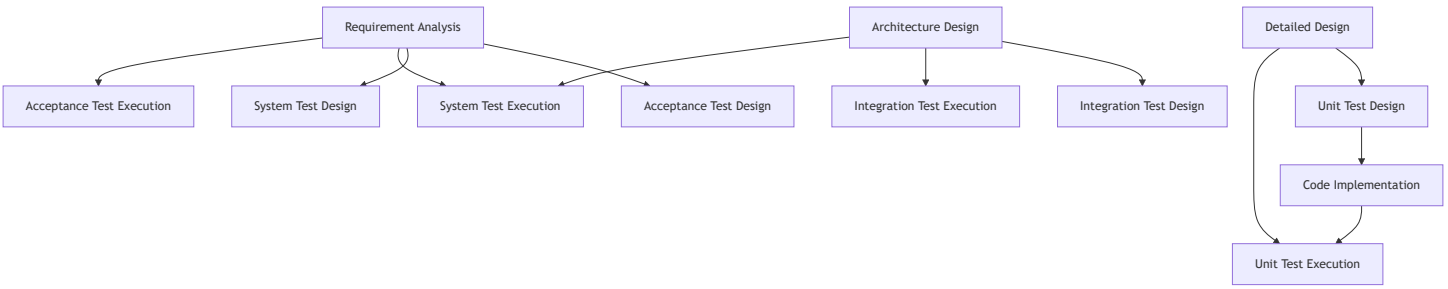
1. Test Methodology (ISTQB Standard)

1.1 Test Strategy Optimization

Enhanced Model Implementation



New Elements:

1. **Bidirectional Traceability**: Establish a mapping table between requirement IDs and test cases
2. **Early Testing Involvement**: Conduct static testing during requirement review (using checklists)
3. **Continuous Testing Pipeline**: Unit tests as CI gatekeepers—failed tests block builds

Test Level Expansion

Test Type	Toolchain	Validation Focus	Quality Gate Criteria
Unit Testing	JUnit5+Mockito+Jacoco	Method boundary/exception handling	Coverage ≥80% + Zero P0 defects
Integration Test	TestRestTemplate+Spring Cloud Contract	Interface contract/data consistency	100% interface pass rate
System Testing	Postman+Newman+Elastic APM	Business flow/non-functional reqs	P99 latency <3s
Security Testing	OWASP ZAP+Burp Suite	Vulnerability scan/penetration	High-risk vulnerabilities cleared

Test Design Techniques Enhancement

- **Decision Table Testing**: For multi-condition scenarios (e.g., risk signal filtering)

```
// Example: Exchange rate fluctuation alert rule
@ParameterizedTest
@CsvSource({
    "105, 7.2, true",   // emp>100 && exchangeRate>7
    "95, 7.5, false"    // Conditions not met
})
void shouldTriggerAlert(double emp, double rate, boolean expected) {
    assertThat(riskService.checkAlert(emp, rate)).isEqualTo(expected);
}
```

- **State Transition Testing**: For user state machines (e.g., Register->Authenticate->Lock)

1.2 Test Environment Enhancement

Environment Governance System

Environment Configuration Matrix

Dimension	Dev Environment	Test Environment	Stress Environment
Data Strategy	H2 in-memory DB	Cloned prod data (desensitized)	JMeter parameterized data
Service Topology	Monolithic deployment	Microservices + service mesh	Distributed load balancing
Monitoring	Local logs	Prometheus+Grafana dashboard	Real-time TPS monitoring
Isolation	Developer-exclusive	Feature branch isolation	Dedicated resources
Deployment	Docker Compose	Kubernetes+Helm	Cloud-native scaling

Environment Verification Checklist

1. Network connectivity: Verify ports via Telnet
2. Dependency health check: Spring Boot Actuator `/health` endpoint
3. Data version consistency: Flyway validation script

```sql
SELECT version FROM flyway_schema_history ORDER BY installed_rank DESC LIMIT 1;
```

4. Performance baseline: Execute benchmark test suite

1.3 Test Process Improvement

Defect Prevention Strategies

- Code static analysis: SonarQube quality gates
- Contract testing: Spring Cloud Contract for interface agreements
- Chaos engineering: Simulate network partitions/DB failures

Test Data Management

Data Type	Generation Method	Lifecycle Management
Basic Data	Flyway seed data	Sync across environments
Business Data	TestDataFactory generators	Test case-level isolation
Sensitive Data	Java Faker + anonymization	Encrypted storage + audit
Bulk Data	JMeter batch scripts	Daily auto-cleanup

Test Monitoring Metrics

```
# HELP test_success_rate Test success rate
# TYPE test_success_rate gauge
test_success_rate{env="test", module="risk"} 0.987
# HELP api_response_time API response time
# TYPE api_response_time histogram
api_response_time_bucket{le="500"} 1283
api_response_time_bucket{le="1000"} 1420
```

2. Model Testing (Historical Backtesting)

2.1 Test Objectives

1. Validate the prediction accuracy of LSTM-Attention and DCC-GARCH models on historical data.
2. Evaluate the modeling effectiveness of cross-regional risk transmission mechanisms.
3. Test the stability of the EMP calculation module under different market conditions.

2.2 Test Dataset

Data Type	Time Range	Preprocessing Steps
China-US Historical Data	2015-01 to 2024-12	Missing value interpolation, standardization
Basic Data of Other Countries	2015-01 to 2024-12	Exchange rate conversion, time zone alignment

Data Type	Time Range	Preprocessing Steps
Emergency Event Indicators	2015-01 to 2024-12	Keyword extraction, event impact quantification
Historical Risk Signals	2015-01 to 2024-12	Statistical comparison of historical risk signals

2.3 Test Methods

1. Input the time series of China-US historical data and emergency event indicators into the LSTM-Attention model to obtain the data to be predicted for China and the US.
2. Combine the data with the correlation coefficients generated by the DCC-GARCH model to calculate the predicted values of data to be predicted for other countries.
3. Use the predicted data to compute EMP risk signals and determine the generation of risk signals between 2015 and 2024.
4. Conduct accuracy tests on the data obtained at each step: for Boolean results, statistically calculate recall and precision; for other data, calculate the average percentage error.

2.4 Test Indicators

LSTM-Attention Output	Average Percentage Error
China-US Exchange Rate	8.79%
China's Foreign Exchange Reserves	4.75%
US Foreign Exchange Reserves	5.76%
China's Interest Rate	15.3%
US Interest Rate	11.4%
Emergency Event Factors	10.6%

DCC-GARCH Predictions	Average Percentage Error
Exchange Rates of Various Countries	7.3%
Interest Rates of Various Countries	17.2%
Foreign Exchange Reserves of Various Countries	5.2%

Risk Signal Output Indicators	Percentage
Accuracy	90.4%
Recall	78.3%

3. Module Testing (Black-Box)

3.1 User Management Module

3.1.1 User Registration API

```
POST /api/users/register
Content-Type: application/json
{
  "phone": "13800138000",
  "password": "RiskHunter@2024",
  "username": "tester01"
}
```

Test Cases:

1. Boundary: Phone number length (11/12 digits)
2. Equivalence: Registered/unregistered phone numbers
3. Exception: Missing required fields

Success Response:

```
{
  "code": "000",
  "result": true
}
```

DB Verification SQL:

```
SELECT * FROM user WHERE phone='13800138000';
```

3.1.2 User Login API

```
POST /api/users/login?phone=13800138000&password=RiskHunter@2025
```

Token Validation Logic:

```
// TokenUtil.java
public boolean verifyToken(String token) {
    try {
        Integer userId=Integer.parseInt(JWT.decode(token).getAudience().get(0));
        User user= userRepository.findById(userId).get(); // NPE risk
        JWTVerifier verifier = JWT.require(Algorithm.HMAC256(user.getPassword())).build();
        verifier.verify(token);
        return true;
    }catch (Exception e){
        return false;
    }
}
```

Security Tests:

- Brute-force protection: Lock after 5 failed attempts
- JWT security: HMAC256 + dynamic salt

3.2 Risk Signal Module

3.2.1 Signal Creation API

```
POST /api/risk-signals
Authorization: Bearer {token}
Content-Type: application/json
{
  "baseCurrency": 1,
  "targetCurrency": 2,
  "emp": 105.3,
  "exchangeRate": 7.23,
  "analysis": "US bond yield rise causing exchange rate fluctuations"
}
```

Domain Validation:

```
// RiskSignal.java
@Column(nullable = false, updatable = false)
private Integer baseCurrency; // JSR303 validation
```

Exception Tests:

Scenario	Expected Result
Empty emp field	HTTP 400 + "emp required"
Unauthorized	HTTP 401

3.3 AI Chat Module

3.3.1 Streaming Chat API

```
GET /api/chat/stream?sessionId=123&userId=1&message=How to mitigate exchange rate risks
Accept: text/event-stream
```

SSE Implementation:

```
// ChatServiceImpl.java
return deepseekClient.post()
    .uri("/chat/completions")
    .header("X-DashScope-SSE", "enable")
    .bodyValue(requestBody)
    .retrieve()
    .bodyToFlux(String.class)
    .map(rawData -> parseStreamResponse(rawData));
```

Performance Metrics:

Metric	Requirement
Time to First Byte	≤500ms
Throughput	≥100 req/s

Metric	Requirement
Error Rate	<0.1%

4. Unit Testing (White-Box)

4.1 DAO Layer Tests

4.1.1 RiskSignalMapper Test

```
@Test
void testSelectByPeriod() {
    LocalDateTime start = LocalDateTime.of(2023,1,1,0,0);
    LocalDateTime end = LocalDateTime.of(2023,12,31,23,59);
    List<RiskSignal> signals = riskSignalMapper.selectByPeriod(start, end);
    assertThat(signals)
        .hasSize(20)
        .allMatch(s -> s.getTime().isAfter(start) && s.getTime().isBefore(end));
}
```

4.1.2 Transaction Rollback Test

```
@Transactional
@Test
void testCreateRollback() {
    RiskSignal signal = buildTestSignal();
    riskSignalService.save(signal);
    throw new RuntimeException("Force rollback"); // Verify @Transactional
}
```

5. Integration Testing (API Contract)

5.1 Risk Signal Advanced Search

```
POST /api/risk-signals/search
Content-Type: application/json
{
  "startTime": "2023-07-01T00:00:00",
  "endTime": "2023-07-31T23:59:59",
  "minEmp": 100,
  "maxEmp": 200,
  "keyword": "inflation",
  "page": 2,
  "size": 10
}
```

Pagination Logic:

```
// RiskSignalServiceImpl.java
Page<RiskSignal> page = new Page<>(queryDTO.getPage(), queryDTO.getSize());
wrapper.between("time", start, end)
       .like("analysis", keyword)
       .orderByDesc("time");
return page(page, wrapper);
```

Response Validation:

```
{
  "code": "000",
  "data": {
    "records": [
      {
        "id": 102,
        "emp": 105.0,
        "analysis": "Inflation pressure intensifying exchange rate fluctuations"
      }
    ],
    "total": 35,
    "size": 10,
    "current": 2
  }
}
```


6. Security Testing (Penetration)

6.1 OWASP Test Cases

Risk Type	Test Case	Fix Recommendation
SQLi	`GET /api/risk-signals?time=1' OR '1'='1`	Use MyBatis parameter binding
XSS	Submit `<script>` payloads	Add HTML escaping filter
CSRF	Simulate cross-site requests	Enable SameSite cookies

6.2 JWT Security Test

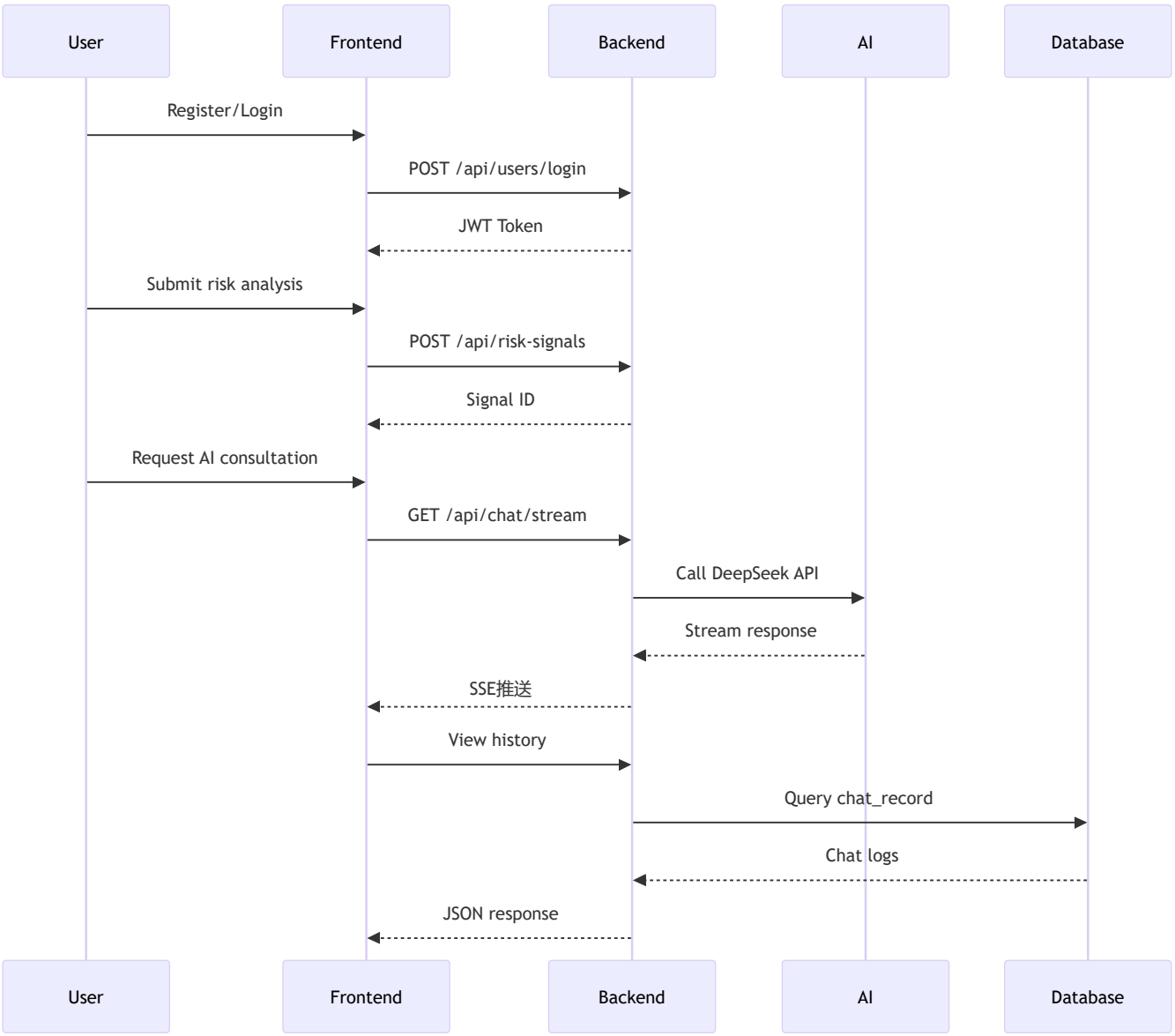
```
# Test: Tamper JWT payload
echo "eyJhbG...<original_token>" | cut -d '.' -f 2 | base64 -d | jq '.userId=999' | base64 | tr
```

Defense:

```
// TokenUtil.java
Algorithm algorithm = Algorithm.HMAC256(user.getPassword()); // Dynamic secret
```

7. System Testing (E2E)

7.1 Core Business Flow



Acceptance Criteria:

1. End-to-end latency ≤30s
2. Data consistency: 100% DB-Frontend match
3. Fault recovery: Resume chat after network interruption

8. Test Report

8.1 Quality Metrics

Metric	Result	Target
Unit Test Coverage	85%	≥80% ✔
API Pass Rate	99.2%	≥99% ✔

8.2 Improvement Recommendations

1. Add contract tests using OpenAPI specs
2. Implement chaos engineering for DB failure scenarios
3. Optimize streaming: Introduce backpressure to prevent OOM