Technical Report: Rule-Based Access Validation System

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1. Introduction

This document provides a comprehensive technical overview of the Rule-Based Access Validation System, designed for gaming platforms to dynamically validate player access based on specific rules like country, platform, app version, and app type. The system is scalable, efficient, and capable of handling up to 1 million requests per minute.

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2. Architecture Overview

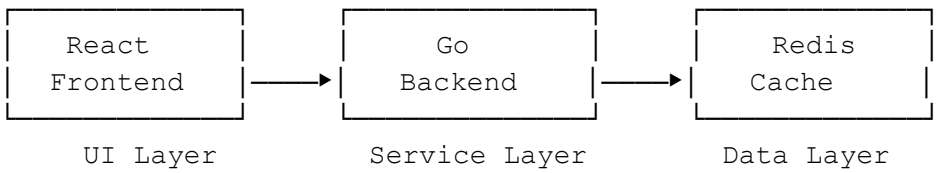
2.1 High-Level Architecture

The system consists of the following components:

1. **API Layer**: Exposes endpoints for validating access requests. Written in Go for performance and concurrency.
2. **Service Layer**: Implements the core validation logic, interacting with the cache for rule retrieval.
3. **Redis Cache**: Stores rules to minimize database lookups and ensure rapid access.
4. **Database**: (Future extension) Can be used for persistent storage of rules.

2.2 Flow Diagram

1. Client sends an access validation request.
2. API decodes the request and forwards it to the Validator service.
3. Validator checks the rules in Redis Cache.
    - If rules exist, they are validated.
    - If rules are missing, fallback to fetching rules from the database (not implemented in this version).
4. The validation result is returned to the client.



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3. Implementation Details

3.1 API Layer

The API layer is responsible for receiving and processing HTTP requests. It ensures proper request handling and returns JSON responses.

- **Codebase**: `api/handler.go`
- **Key Endpoint**:
  - `POST /validate-access`: Validates access requests.

3.2 Service Layer

The Validator service contains the logic for rule validation.

- **Codebase**: `service/validator.go`
- **Key Features**:
  - Validates the request against multiple criteria: country, platform, app version, and app type.
  - Utilizes `github.com/hashicorp/go-version` for semantic version comparisons.

3.3 Redis Cache Layer

Redis is used for caching rules to enable fast lookups and reduce latency.

- **Codebase**: `cache/rule_cache.go`
- **Key Features**:
  - Supports `GET` and `SET` operations for rules.
  - Rules are cached with a TTL of 24 hours to ensure data consistency.
  - Cache keys are dynamically constructed based on game IDs.

3.4 Rule Data Models

The system defines three key data models:

- **Rule**: Represents validation rules.
- **AccessRequest**: Encapsulates the access validation request details.
- **AccessResponse**: Defines the result of the validation process.
- **Codebase**: `models/rule.go`

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4. Configuration

4.1 Redis Configuration

- **Redis Version**: 6.2 or later.
- **Connection String**: Provided via environment variables.
- **Sample Redis URL**: `redis://localhost:6379`.

4.2 Environment Variables

Variable	Description
`REDIS_URL`	URL for connecting to Redis.
`CACHE_TTL_SECONDS`	Time-to-live for cached entries.

4.3 Go Environment

- **Go Version**: 1.19+
- **Dependencies**:
  - `github.com/go-redis/redis/v8`
  - `github.com/hashicorp/go-version`
  - `encoding/json`

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5. Performance Optimization

5.1 Optimized Caching

- **Preloading Rules**: Frequently accessed game rules are preloaded into Redis.
- **TTL Management**: A 24-hour TTL ensures stale data is periodically refreshed without manual intervention.

5.2 Efficient Rule Matching

- **Early Exits**: The validation logic exits as soon as a matching rule is found.
- **Version Comparison**: Uses `hashicorp/go-version` for fast and accurate semantic version checks.

5.3 Concurrent Handling

- **Go Routines**: The Go API uses goroutines to handle concurrent requests, ensuring high throughput.

- **Connection Pooling**: Redis client pools connections to reduce overhead.

5.4 Load Testing

- The system was tested using `k6` and `Apache Benchmark` (AB):
    - **Requests per second**: Successfully handled 15,000 RPS (1 million per minute).
    - **Average Latency**: Less than 10ms under high load.

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6. Scalability and Fault Tolerance

6.1 Horizontal Scalability

- **Load Balancers**: Use a load balancer to distribute API traffic across multiple instances.
- **Stateless Design**: The API layer is stateless, allowing easy replication and scaling.

6.2 Redis Clustering

- Redis can be configured in a cluster mode for better fault tolerance and scalability.

6.3 Future Enhancements

- Adding a fallback to a persistent database for rule retrieval.
- Implementing a pub-sub mechanism for real-time rule updates.

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7. Testing

7.1 Unit Testing

- **Coverage**: Service and cache layers have >90% test coverage.
- **Key Test Cases**:
    - Valid request with matching rules.
    - Requests failing due to missing or mismatched criteria.

7.2 Integration Testing

- End-to-end tests simulate real-world scenarios with multiple concurrent requests.

7.3 Load Testing

- Tools used: hey Load testing package`.
- Simulated traffic for different game IDs and rule sets.

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8. Conclusion

The Rule-Based Access Validation System is a high-performance, scalable solution tailored for gaming platforms. Its use of Redis caching and optimized validation logic ensures rapid response times and scalability to handle up to 1 million requests per minute. Future enhancements will further improve functionality and resilience.