ICSQuiz

Project Proposal

A Modern, Scalable Online Exam Platform

PREPARED BY

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🎓 ICS Quiz System — Solution Overview

Scalable Two-Service Architecture for 50,000+ Concurrent Students

📊 The Problem

- ✗ **Existing systems crash under load**
- ✗ High exam traffic causes server failures
- ✗ Slow result processing
- ✗ 50,000+ concurrent students expected
- ✗ DB write spikes (5M submissions)
- ✗ Login timeouts, MCQ delays
- ✗ **Need: Scalable, Secure, Modern Solution**

✅ Our Solution

- ✓ **Two Independent Services:**
- ✓ 🟢 Login + Analytics (read-heavy)
- ✓ 🔵 Submission Service (write-heavy)
- ✓ Queue-based buffering (RabbitMQ)
- ✓ Batch DB writes (100x faster)
- ✓ Multi-layer caching (CDN+Redis)
- ✓ Independent scaling & failover

⭐ Key Benefits

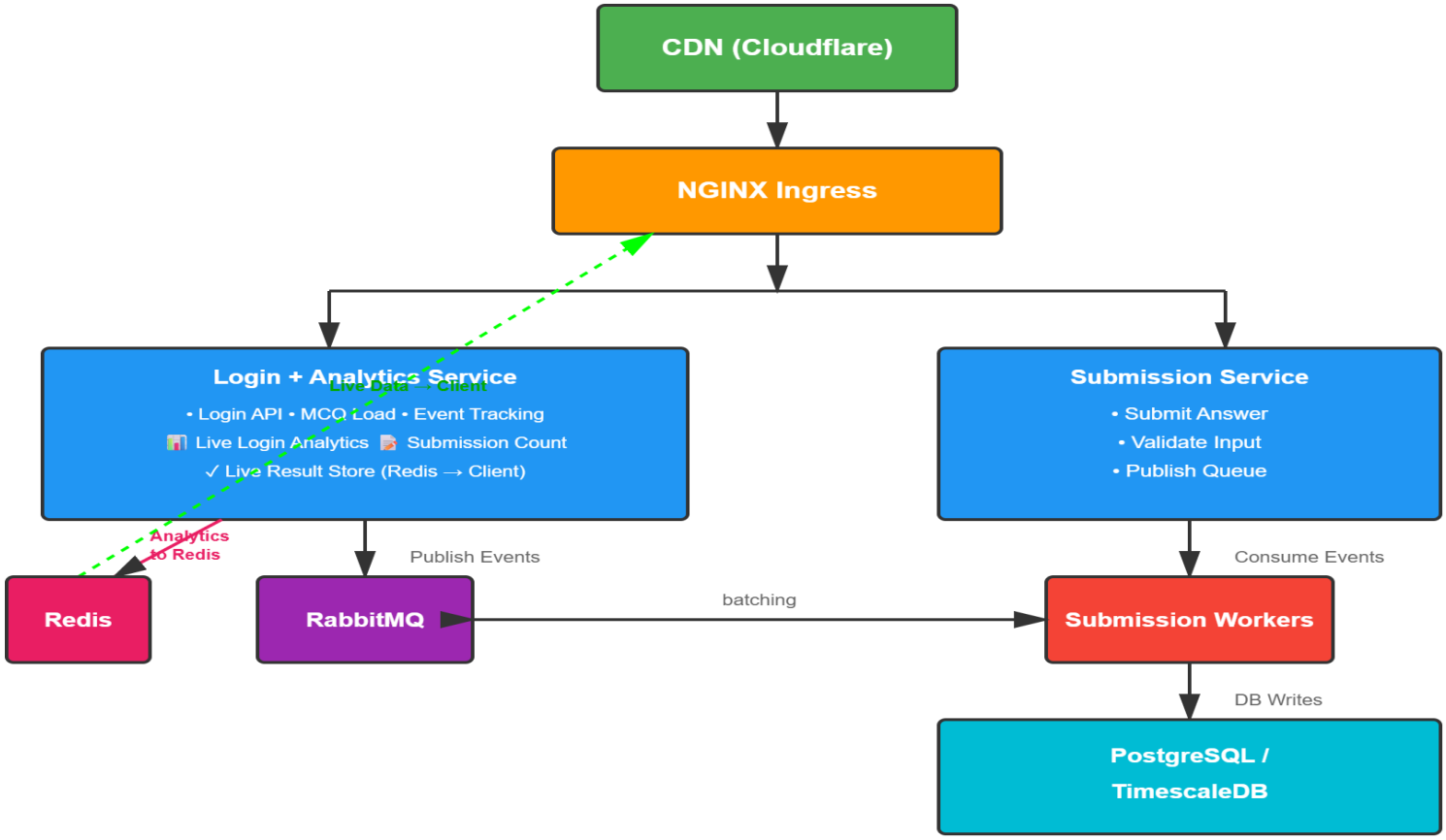
- ★ ✓ 30-50k submissions/sec
- ★ ✓ Login latency: <80ms
- ★ ✓ MCQ load: <10ms (cached)
- ★ ✓ 100% submission durability
- ★ ✓ 40% cheaper (24-30GB RAM)
- ★ ✓ Zero data loss on failures

🏗️ Architecture Flow

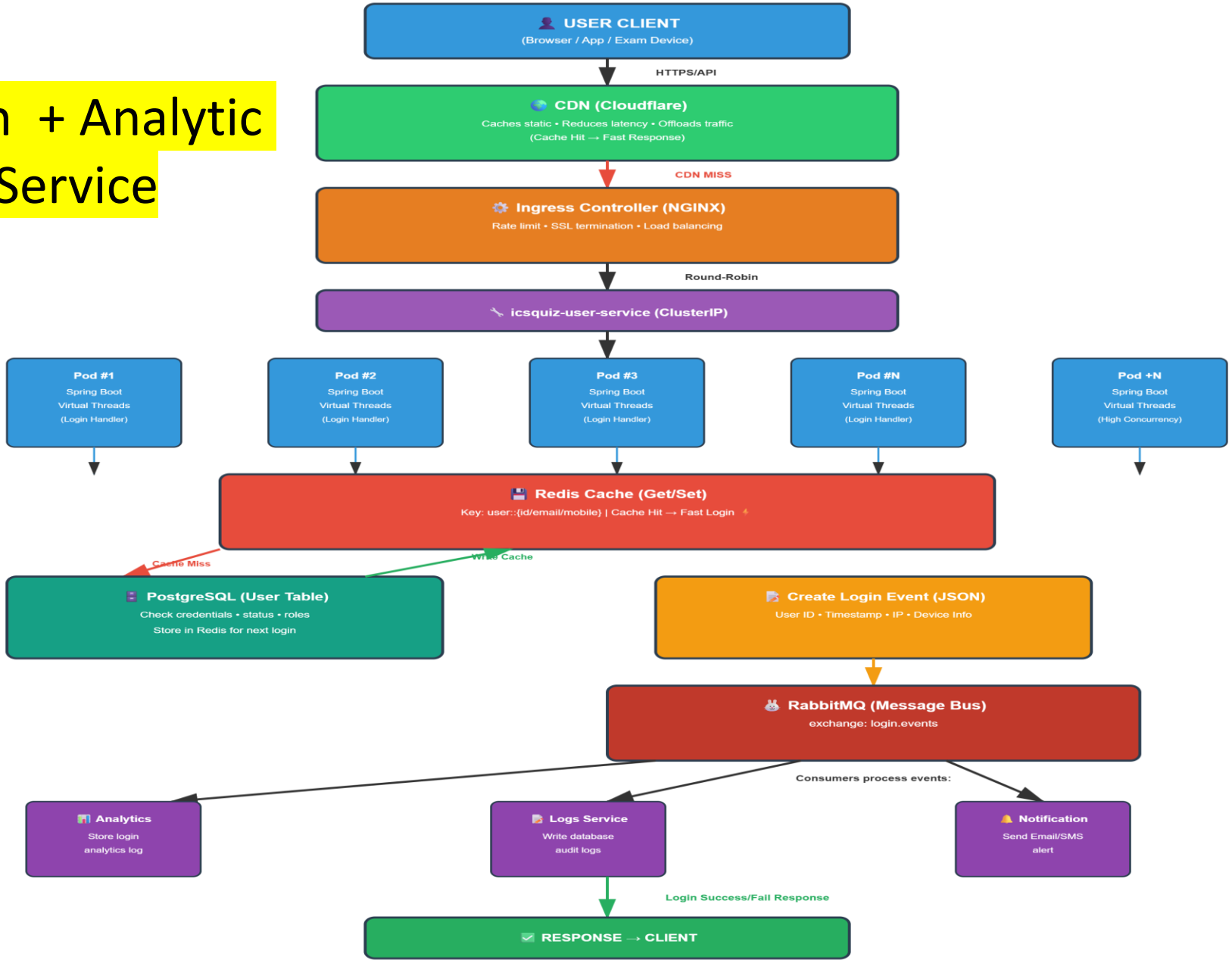
CDN → NGINX → Login Service → Redis

Submission API → RabbitMQ → Workers → PostgreSQL

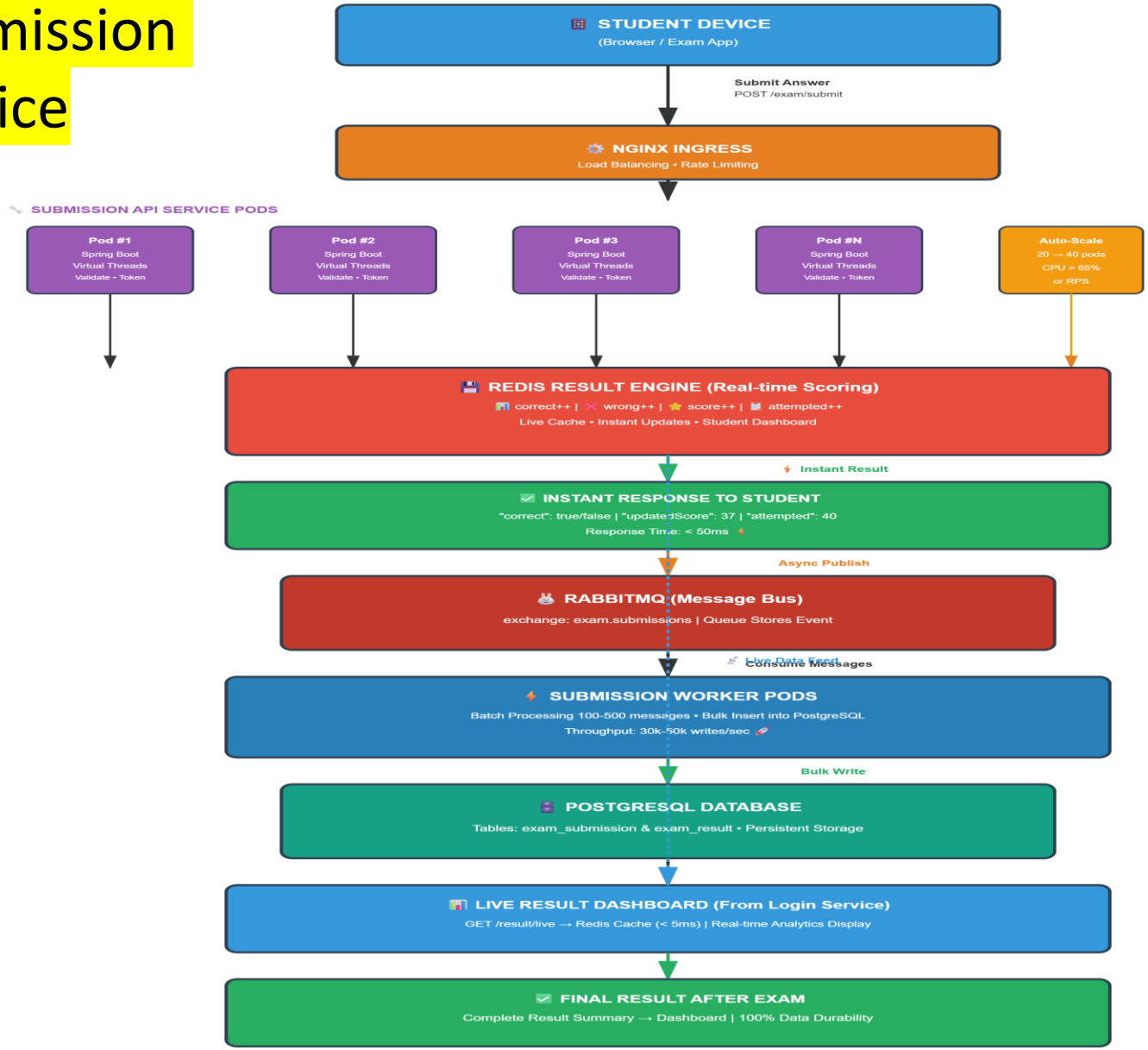
High-Level Architecture



Login + Analytic Service



Submission Service



Complete Database Schema

ICS Quiz System - 7 Subsystems, 17 Tables

USER MGMT

USERS
user_id, username
password, role
status, created_at

ADMIN_LOGS
log_id, action
entity_type, admin_id

PACKAGES

PACKAGES
package_id, name
duration, pass_mark
max_concurrent

CATEGORIES
category_id, name
total_questions

ANALYSIS
total_examinee
passed, failed

QUESTIONS

QUESTIONS
question_id, text
marks, negative_mark

Q_OPTIONS
option_id, text
is_correct

Q_COLLECTION
question_id, option_id

EXAMS

EXAMS
exam_id, name
status, duration

USER_ANSWERS
answer_id, is_correct
marks_obtained

RESULTS
total_questions
percentage, marks

COLLECTIONS

USER_SUBMITTED
answer_id, option_id

USER_SELECTED
answer_id, option_text

ANSWER_DETAILS
answer_id, answer_text

COMMUNICATION

MESSAGES
message_id, subject
sender_id, recipient_id

NOTIFICATIONS
notification_id, type
title, description

ACCESS

USER_PACKAGES
user_package_id
access_type

INSTRUCTIONS
instruction_id
instruction_text

17	7	100+	✓
TOTAL TABLES	SUBSYSTEMS	RELATIONSHIPS	FULLY NORMALIZED

Technology Stack

Modern, Scalable, Production-Grade Architecture

BACKEND

- Java 25
- Spring Boot 4
- Redis Cache
- PostgreSQL
- RabbitMQ
- Virtual Threads

FRONTEND

- React
- Angular
- Responsive UI
- Modern Design
- Fast Performance
- Secure

DEVOPS

- Docker
- K3s Kubernetes
- GitHub Actions
- Jenkins CI/CD
- Helm Charts
- Secret Management

MONITORING

- Prometheus
- Grafana
- ELK Stack
- Alerting
- Metrics
- Tracing

Concurrency Strategy

Handle 50,000+ Concurrent Students

❌ Traditional Approach

- ☐ Thread-per-request model
- ☐ 1 thread = 1 MB+ memory
- ☐ 50,000 threads = 50GB RAM needed
- ☐ Context switching overhead
- ☐ GC pauses cause timeouts
- ☐ Limited concurrency (max 1-2k threads)

✅ Virtual Threads (Project Loom)

- ✓ 1 virtual thread = ~10 KB memory
- ✓ 50,000 threads = 500 MB RAM only!
- ✓ Lightweight & structured concurrency
- ✓ Zero GC pause overhead
- ✓ Millions of threads possible
- ✓ Spring Boot 4.0+ native support

Virtual Threads

Lightweight
Non-blocking I/O
Structured Tasks

Thread Pool

CPU Cores × 2
Cached Executor
Task Queuing

Message Queue

RabbitMQ Buffering
Batch Processing
Decouple API ↔ DB

Total RAM for 50k Concurrent Students

Complete Stack Breakdown - Realistic & Production-Ready

Component-wise Breakdown

COMPONENT	RAM
Login + Analytics	4-6 GB
Submission Service	12-16 GB
Redis Cache	1 GB
RabbitMQ Queue	2 GB
PostgreSQL DB	3-4 GB
OS + K3s System	2 GB
TOTAL (REALISTIC)	**24-30 GB**

RECOMMENDED SETUP

32 GB

HA buffer + future growth

MINIMUM SETUP

24 GB

Production ready

PER STUDENT

~0.5 MB

Cost-effective scale

💰 Infrastructure Pricing

Cloud VPS Plans for 50,000+ Concurrent Students

BUDGET SETUP (COMBINED)

CLOUD VPS 30+20

2 Smaller Instances

~~$40.00~~

$32 .80 /month

Configure

✓ 14 vCPU Cores (combined)

✓ 32 GB RAM (combined)

✓ 300 GB NVMe SSD

✓ 900 Mbit/s Port

FOR 50K STUDENTS

SINGLE INSTANCE SETUP

CLOUD VPS 40

~~$26.00~~

$20 .80 /month

Configure

✓ 12 vCPU Cores

✓ 48 GB RAM

✓ 250 GB NVMe SSD

✓ 800 Mbit/s Port

PREMIUM SETUP

CLOUD VPS 50

High Availability

~~$46.00~~

$36 .80 /month

Configure

✓ 16 vCPU Cores

✓ 64 GB RAM

✓ 300 GB NVMe SSD

✓ 1 Gbit/s Port

💰 Revenue & Cost Analysis

ICS Quiz System - Financial Projections & Savings

📊 Monthly Cost

MINIMUM PLAN

$32

VPS 30+20 (32GB RAM)

MAXIMUM PLAN

$120

VPS 50 + Premium (64GB RAM)

Range: $32–$120/mo

Based on usage & load

🎯 Annual Savings

VS TRADITIONAL SETUP

$1,300

Minimum annual savings

MAXIMUM SAVINGS

$1,600

With premium setup

Save: $1,300–$1,600/year

Compared to monolithic

📈 Key Metrics

ROI

40x

Return on infrastructure

PER STUDENT

$0.0004

Cost per exam session

PAYBACK PERIOD

1 month

Full cost recovery

Thank You!