CPIT- 455: Software engineering (II)

Dependable Systems Assignment

Online Exam Platform

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1. Concept

Introduction

An online exam platform is critical for educational institutions and certification authorities. Exams are time-bound and high-stakes, meaning any system failure can directly affect fairness, trust, and institutional credibility. Students must be able to access the platform on time, submit their answers reliably, and have their data protected. To achieve this, the platform must meet five key dependability requirements: **Availability, Reliability, Safety, Security, and Resilience**.

1. Availability

Requirement: The system must remain operational during scheduled exams with minimal downtime.
Justification: Exams have fixed durations. Any period of unavailability can disadvantage students and disrupt assessment schedules.
Example: For a two-hour exam, even 10 minutes of downtime could affect thousands of participants. Availability also ensures that exam submissions are received and recorded on time without delays.

2. Reliability

Requirement: The platform must deliver exam questions correctly and record student responses without error or loss.
Justification: Inconsistent timers, session errors, or lost answers compromise exam integrity and fairness.
Example: If a student completes a set of questions but the answers are not saved due to a system fault, the result cannot be trusted. Reliability also extends to the continuous delivery of content, ensuring the system behaves consistently for all users.

3. Safety

Requirement: The platform must prevent harm to student's work, exam results, and overall exam process.
Justification: Safety protects against lost submissions, accidental deletions, or scoring errors that could affect academic outcomes.
Example: If a server crash occurs during an exam, mechanisms must exist to recover answers, maintain scoring consistency, and avoid unfair treatment of students. Safety includes both operational safeguards and preventive measures to avoid critical failures.

4. Security

Requirement: Exam content, student data, and proctoring recordings must be protected from unauthorized access or tampering.
Justification: Unauthorized access or data leaks compromise the credibility of the institution and the validity of the assessment process.
Example: Question banks, student answers, and examination logs must be encrypted and accessible only to authorized personnel. Security also covers secure transmission of exam data and protection against cyberattacks targeting exam availability or integrity.

5. Resilience

Requirement: The system must continue functioning or quickly recover in the event of component or network failures.
Justification: Even if parts of the platform fail, exams should not be canceled or disrupted, ensuring fairness and continuity.
Example: If a primary data center experiences downtime, traffic should automatically reroute to a secondary center with minimal impact. Resilience includes redundancy, failover mechanisms, and local caching to allow students to continue working offline until the system is restored.

2. Implementation

Designing a dependable online exam platform requires balancing ease of use with strong technical safeguards. The system must support thousands of students logging in at the same time, protect against errors or failures, and ensure that no exam data is lost or manipulated. In this design, the focus is on redundancy, diversity, and security features that directly support the CIMT dependability dimensions: **availability, reliability, safety, integrity, and timeliness**.

System Overview

The system is divided into four main components, each playing a role in ensuring dependability:

1. **Student Interface** – Students access exams through a web browser or a mobile application. Both interfaces are designed to work under different conditions, including low bandwidth. To handle poor connections, the system saves answers locally every 30 seconds, then uploads them when the internet is restored. This prevents lost progress and supports **reliability**.

2. **Exam Server** – The core application runs on multiple servers that share traffic through a load balancer. Since the services are stateless, any server can process a request without depending on another. This makes it possible to add more servers during peak exam times, ensuring **availability** and **timeliness**.

3. **Database System** – All student data, exam questions, and results are stored in a secure database. A backup database is continuously synchronized, ready to take over if the main one fails. This protects both **integrity** and **availability**.

4. **Admin Panel** – Instructors and administrators use a separate portal to schedule exams, upload questions, and review results. Access is restricted with multi-factor authentication, reducing risks of unauthorized actions and supporting **safety**.

Redundancy Design

Redundancy is used to prevent single points of failure:

1. **Multiple Servers** – At least three servers run the exam application. If one server goes down, the others continue to handle traffic, and students are not affected. This provides **fault tolerance** and improves **availability**.

2. **Database Backup** – A hot-standby database mirrors the primary in real time. If the primary fails, the backup automatically becomes active with almost no downtime. This ensures **reliability** of exam data.

3. **Answer Auto-Save** – Student answers are saved both locally and on the server. Even if a student's internet connection drops for a few minutes, the local cache ensures no answers are lost. This protects **safety** and **timeliness**.

4. **Content Delivery Network (CDN)** – Exam questions and resources are distributed across a CDN. Students connect to the nearest server node, reducing delays and ensuring smooth delivery even during heavy usage.

Diversity Design

Diversity protects the platform from depending on a single solution:

1. **Cloud + Local Backup** – Primary hosting is in the cloud, but a local backup server at the university data center can run exams if the cloud provider experiences downtime. This ensures **service continuity**.

2. **Multiple Internet Providers** – Data centers are connected through at least two ISPs. If one provider goes offline, traffic is automatically routed through the second. This keeps exams **available** without interruption.

3. **Browser and Device Diversity –** The platform supports multiple web browsers and mobile devices. If a compatibility issue arises with one browser or device, students can continue the exam using an alternative supported option. This reduces single points of failure related to software or hardware.

4. **Data Storage Diversity** – Exam submissions and logs are stored in two types of storage: a relational database and a separate immutable log. This way, even if one storage method is compromised, the other provides evidence of exam activity.

Security and Dependability Features

Several safeguards are included to support confidentiality, fairness, and accountability:

1. **Role-Based Access Control (RBAC):** Students, teachers, and administrators each have different permissions. For example, teachers can upload questions but cannot change results after submission, protecting **integrity**.

2. **Encryption:** All data in transit is protected with TLS, and stored data is encrypted. This ensures that even if data is intercepted, it cannot be misused, supporting **safety**.

3. **Audit Logs:** Every event, such as student login or exam submission, is logged securely. These logs cannot be altered and serve as proof in case of disputes, strengthening **reliability**.

4. **Failure Handling:** If part of the system fails, exams continue without interruption. For instance, if a proctoring module crashes, exams are not stopped; instead, monitoring continues with alternative methods. This ensures **availability**.

3. Measurement

Availability is calculated as:

Availability = MTBF / (MTBF + MTTR)

We Assume:

MTBF = 5000 hours

MTTR = 0.5 hours

A= 5000 /5000+0.5

3.2 Service Level Agreements (SLAs)

Availability: ≥ 99.99% during exam windows

Downtime: Yearly 52m 36s **| Monthly** 4m 23s

Response Time: < 2 seconds for page load

Recovery Time: < 1 hour for any critical failure

These SLAs ensure that the system meets the dependability expectations for students and faculty.

4. Trend

Future Evolution :

In the next five years, the online exam platform can evolve to further improve dependability, security, and user experience:

1. **AI-Based Proctoring:**
   AI tools can monitor exams in real time to detect suspicious behavior, reducing reliance on human proctors while maintaining **integrity**.

2. **Blockchain Records:**
   Immutable records of submissions and results can strengthen data **integrity** and transparency, preventing tampering and disputes.

3. **Personalized Accessibility Features**
   The platform could adapt exams to student's needs Like visually impaired students getting screen reader support or extended time automatically. This ensures fairness while making the system more inclusive.

4. **Enhanced Security:**
   Biometric authentication and anomaly detection can further protect against unauthorized access, maintaining **safety** and **reliability**.