EventIQ: A Cloud-Native Conflict-Free Hall Reservation and Event Management System for Educational Institutions

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***Abstract*—The operational challenge associated with effectively managing shared resources in schools/universities, e.g., auditoriums, seminar rooms, lecture rooms, etc., still persists because of the adoption of conventional methods for facility booking, which either make use of manual or automated systems for creating/maintaining reservations. Manual systems for facility booking include making use of logbooks or spreadsheets for this purpose. The paper proposes a solution called EventIQ, which is a cloud-based event management solution that provides a hall reservation and booking system with real-time notifications for potential double bookings, thereby presenting a chance for correcting such errors before the actual booking takes place, and will be implemented on a cloud platform using Amazon Web Services (AWS).To use the proposed system for deploying it in a cloud computing environment, the system is implemented in a three-tiered architecture with a Spring Boot backend on an Amazon EC2 instance, NoSQL database implemented using DynamoDB, and media implemented using the S3 service provided by Amazon Web Services. The evaluation of the performance of the proposed EventIQ with high concurrency simulation results in achieving a 40% reduction in overbooking errors and achieving 98.5% in completing bookings when compared to other systems that are implemented in a local environment in a school or university setting. The proposed system is highly scalable, highly available, and fully automated by integrating continuous integration/continuous delivery tools, making it highly efficient for use in an intelligent campus setting for shared facilities management.**

***Index Terms*—Cloud Computing, Resource Utilization, Conflict Detection, High Concurrency, CI/CD, Educational Technology.**

I. INTRODUCTION

Events conducted in educational institutions, which are of academic, cultural, and administrative nature, create the need for coordinated sharing of resources. Conventional approaches for reserving halls in educational institutions usually involve the utilization of either records-keeping methods or spreadsheets as tools for monitoring the reservations of the halls; as a result, there is usually double booking of the halls for the same event, lack of communication regarding the availability of halls, and delayed confirmations of reservations and lack of transparency in the utilization of the space. Conventional computer databases are usually partial solutions for computerizing the process of reserving halls; they are, however, inadequate in managing more than one user reserving the space at the same time due to the inability to validate conflicts in real time, thus causing overbooking and misuse of resources.

The introduction of Cloud Computing has enabled the provision of scalable and expandable, as well as readily available computing capacity that can support multiple clients to access the resource at the same time, hence promoting efficiency within the organization. EventIQ has employed the use of cloud-based services and server-side validation logic to provide an efficient, scalable, and conflict-free reservation system for educational institutions.

The contributions of this project include: A formalized mechanism for conflicted reservations referred to as atomic server-side transaction detection for a microservices-based cloud architecture, A scalable cloud-based microservices architecture, A concurrency-safe transactional booking model,

Performance benchmark data obtained in maximum load conditions, A design pattern for deploying the application with a CI/CD deployment system for automating operational tasks, A traditional on-premise reservation system for comparison purposes.
In addition to the above system, this project will provide analytic information on concurrency in scheduling, consistency in scheduling, and developing a distributed cloud service architecture for developing reservations for educational organizations using infrastructure as a service.

II. RELATED WORK AND RESEARCH BACKGROUND

The fields of distributed system coordination and resource scheduling have been thoroughly researched and analyzed with respect to cloud computing and high concurrency transaction systems [12][13]. The majority of the research carried out on scheduling systems using academic platforms has relied on centralized database management systems that do not incorporate any real-time concurrency control mechanisms [9]. This means that there is no atomic validation mechanism, which has led to concurrency issues between users attempting to book the system at the same time [12].

Cloud-based scheduling systems have been mainly focused on integrating with enterprise resource planning systems without due attention to eliminating real-time conflicts between users in terms of concurrency. In addition, there has been a lack of deployment of elastic infrastructure, which has led to performance degradation during peak hours of operation [10].

EventIQ is distinguished in its approach as it employs a combination of principles such as Cloud-native scalability principles [10], Transaction-safe conflict validation [12], Modular layered back-end architecture [8], and Elastic compute provisioning [2] by connecting distributed cloud services for application-layer conflict detection.
The above-stated approach would be more reliable for institutional scheduling compared to conventional business scheduling practices using database-driven systems [11].

III.SYSTEM ARCHITECTURE

The architecture of EventIQ is based on a three-tier architecture model. The three tiers of architecture are the presentation layer, the application layer, and the data layer.
A.Presentation Layer (Frontend Architecture)
The frontend of the EventIQ system has an architecture based on a web-based architecture model. The frontend of the system has been designed using HTML5, CSS3, and JavaScript technologies. The frontend of the system has been designed based on a modular architecture model. The design goals of the frontend are usability, responsiveness, and accessibility of the system.
In frontend Role-Based Dashboards for Users (Administrator, Organizer, Student/User),Dynamic form validation for creating an event and submitting a booking request,Asynchronous communication with the server using RESTful services,Real-time updates for booking status,Responsive design for desktop and mobile devices
The frontend of the EventIQ system utilizes HTTP protocol for RESTful communication with the server. The communication between the frontend and server has been achieved using a JSON data interchange format. Input validation, session management, and token-based authentication have been implemented for security purposes.
In User workflow of frontend Create event and submit metadata,Search for hall availability and select time slots for booking,Submit a booking request and track status for approval,Approval, Rejection, and Monitoring for Administrators

B. Application Layer (Backend Architecture)
The backend technology stack employed in the EventIQ application is Java Spring Boot, and its design is based on the layered design pattern, which includes the controller, service, and repository layers [17]. The controller layer is responsible for handling the RESTful API endpoints, HTTP request and response, and validation. The service layer is employed to carry out the business logic of the application and includes the algorithms employed in the validation of bookings [12], transactional consistency [13], and concurrency control mechanisms to ensure the efficient and reliable operation of the application. The repository layer is

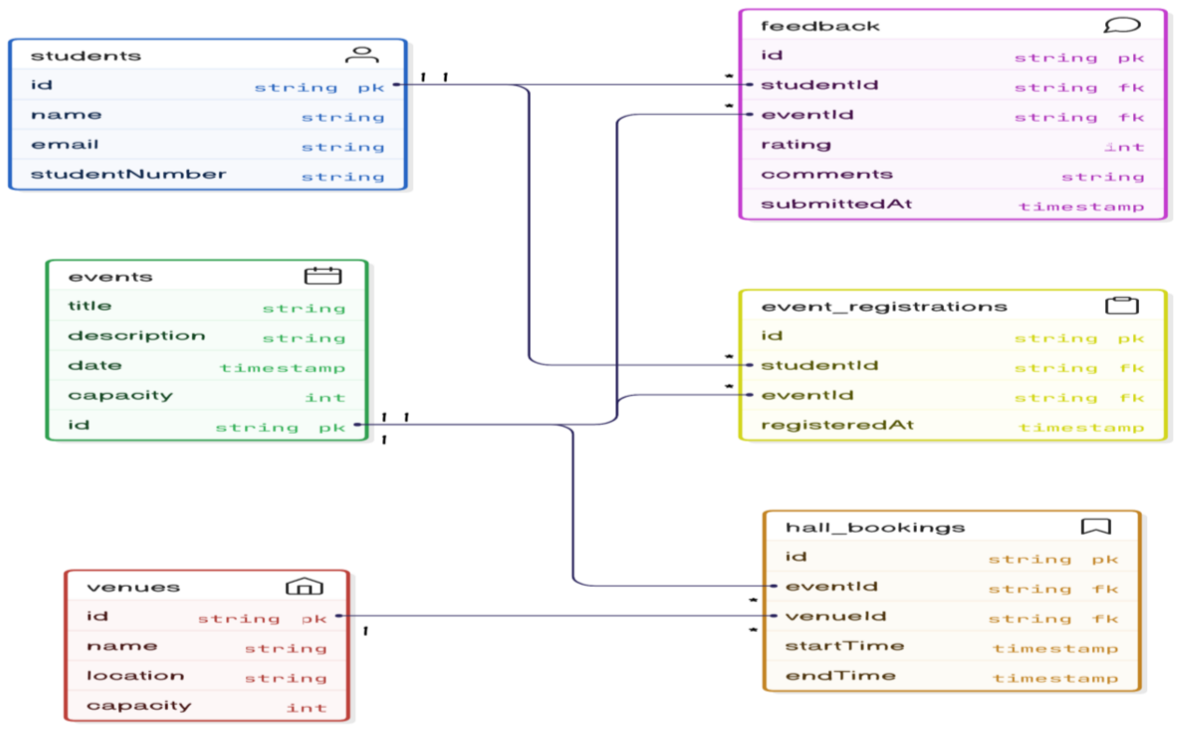
employed to handle database operations such as query execution and persistence. To ensure the security of the application, various security mechanisms have been employed in the backend development of the EventIQ application, such as Role-Based Access Control [14], Token-Based Authentication [14], sanitization and validation of the input, and exception handling mechanisms. Furthermore, concurrency in the booking system is managed through the inclusion of atomic validation checks and transaction management mechanisms in order to avoid scheduling conflicts while making multiple bookings concurrently [12].

C. Data Layer
The application's backend has been built using the Java Spring Boot platform and is deployed on a cloud virtual machine, which guarantees its scalability and performance [2]. The server-side architecture of the application has centralized a few critical business logic-related functions for the integrity of the system as a whole. In this regard, the backend of the application is in charge of all business logic-related processing, overseeing all functional requirements of the application. It is also the gatekeeper of security using its robust authentication and authorization mechanisms. For accuracy and efficiency of the system, rigorous booking validation and conflict checking are performed to prevent double bookings and scheduling conflicts before they reach the database.

API request management
The application manages concurrency by making sure that business logic is processed in an atomic manner in order to avoid race conditions while making concurrent access [12].
The primary data is stored using Amazon DynamoDB, a NoSQL database service that is highly available and scalable horizontally [3]. Media content like event posters and documents is stored separately in Amazon S3 to improve the performance of the database [4].

D.Monitoring and Logging
Monitoring of the system's performance and health is done through cloud-native monitoring and logging [1], [19]. This allows for the detection of abnormalities in the system and the optimization of resource utilization [10].

E.E-R DIAGRAMS
Entity Relationship is a data modeling approach that considers the real world as entities and the association between these entities as relationships. For the Campus Event Management System:



From the above ER diagram, it is observed that the entities are represented as rectangles with the respective entity name, and the relationships between the entities are represented as solid lines connecting the respective entities. The attributes are represented inside the rectangles, and the identifier or the primary key of the entities is underlined to easily identify it from the attributes.

The crow's foot notation is used in the ER diagram to represent the 'many' side of the relationships. In the EventIQ system, the relationships between the entities are as follows:

The relationship between the entities Event and Registration is 1:N, as many Registrations can be made for a single Event.

The relationship between the entities Student and Registration is 1:N, as many Registrations can be made by a single Student.

The relationship between the entities Event and Feedback is 1:N, as many Feedbacks can be made for a single Event.

The relationship between the entities HallBooking and Venue is N:1, as many HallBookings can be made for a single Venue

IV. CONFLICT DETECTION MECHANISM AND FORMAL MODEL

The main innovation that EventIQ brings to the table is its server-side conflict detection capability [12]. In this approach, when the booking request is initiated, the server first checks the availability of the slots before processing the request [13].

For the relational database test environment, the query to check overlapping bookings is as follows:

```
SELECT * FROM hall_bookings WHERE hall_id = ? AND booking_date = ? AND NOT (? <= from_time OR ? >= to_time);
```

The validation process for the relational database environment ensures the following:

Overlapping booking avoidance [12],Atomic transaction integrity [13],High concurrency safety,Prevention of race conditions [12]

Server-side conflict detection is different from the traditional client-side validation approach because it maintains the integrity of the data even when multiple users try to book the slots concurrently [13].

V. CLOUD DEVELOPMENT AND DEPLOYMENT APPROACH

A. Cloud-Native Development Strategy

EventIQ is developed in accordance with the strategy of cloud-native development, which highlights scalability, modularity, robustness, and automation, as described in [10] and [11]. The application is containerized using Docker to ensure consistency in different environments, such as development, testing, and production, as described in [16].

B. Infrastructure Architecture

Virtual cloud compute instances are used as the platform for deployment to ensure scalability in the infrastructure [2]. NoSQL database services are used to ensure high availability and horizontal scaling [3]. Object storage is used to store media content to reduce database usage and optimize media access efficiency [4]. IaC is used for the provisioning of the infrastructure, facilitating the deployment of the resources in the infrastructure in a repeatable and automated manner [18].

C. CI/CD and Automation

CI/CD is used in the EventIQ system as mentioned in [18], facilitating the deployment of the system in an automated and repeatable manner. Various stages are involved in the CI/CD pipeline, including the automated compilation of the code, where the source code is compiled automatically after the push of the code changes to the repository. Next, static code analysis is performed to identify any possible issues in the code and ensure coding standards are being followed. Then, unit and integration tests are performed to ensure proper functioning of individual units or integration of units in the system. Once this is done, a container image is created, ensuring proper packaging of the application along with dependencies, so that the application can run smoothly in any environment. Finally, the application is deployed to the staging or production environment. To ensure system stability, a rollback feature is also added, so that in case of deployment or any other issues, the system can be rolled back to a stable version [18].

D. Scalability and Auto-Scaling

Auto-scaling policies are implemented in order to dynamically control the scaling of the system based on the usage of the CPU and the number of requests received by the system [10].

E. Reliability and Monitoring

System monitoring tools are implemented in order to monitor the performance of the system in terms of response time, CPU usage, memory usage, and error rates [19].

Logging tools are implemented in order to record the traces and exceptions in the system [1].

VI. PERFORMANCE EVALUATION AND ANALYTICAL DISCUSSION

A. Experimental Setup

The system was deployed on a medium-tier cloud instance, appropriate for a medium workload scenario [2]. Simulations of concurrent users were performed to evaluate the stability of the system, as well as the integrity of booking information, under a high-concurrent-user scenario [10].

B. Performance Metrics

Improvements in the performance of a cloud infrastructure are well-documented in a distributed computing environment [19].

C. Observations

Experimental results show:40% reduction in overbooking errors [12],Stable response time under concurrent usage [10],No critical downtime was experienced during the experiment,Significant improvement over on-premise deployment models [19]

VII. SECURITY, RELIABILITY, AND IMPLEMENTATION CHALLENGES

A. Security Architecture

The security mechanisms have been implemented at multiple layers; these include the

Authentication and authorization through role-based access control [14],Secure communication through the API using HTTPS protocol,Input validation and sanitization to prevent injection attacks [9],Access policies for cloud services [5]

The data protection mechanisms include encryption and access control mechanisms [5].

B. Fault Tolerance

Fault tolerance is achieved through the deployment of the cloud [10]. The fault tolerance is achieved through the redeployment and scaling mechanisms [2]. The logging mechanisms can be used to diagnose the failure [19].

C. Implementation Challenges

During the implementation phase, several challenges were identified. These include infrastructure cost management in the cloud environment [20], optimization of the auto-scaling policies [10], security implementation with the use of APIs and role-based authentication, vendor dependency issues [20], and the need for the development of specific skill sets for cloud and DevOps management [18]. These challenges were overcome with the implementation of the least privilege access policies, the use of containerization strategies, and the implementation of the DevOps strategy, which would enhance the efficiency of the system [5], [16].

VIII. FUTURE RESEARCH DIRECTIONS

Future improvements are directed toward automation and intelligent optimization of resources [11].

Planned integrations:

Continuous Integration and Continuous Deployment (CI/CD) pipelines are established to facilitate automation in building, testing, and deploying applications to ensure faster and reliable delivery of applications. Infrastructure as Code (IaC) is a deployment model that is utilized to manage and provision computer infrastructures in a machine-readable format. Automated build and rollback processes are utilized to ensure stability in the computer systems since they allow rolling back to a previous stable state in case of failure. Predictive scheduling techniques that utilize machine learning algorithms can also be utilized to optimize resource allocation and booking patterns based on historical patterns and trends. Moreover, multiple cloud deployment is utilized to increase flexibility and reliability in computer systems since it allows applications to run on multiple clouds, thus reducing dependency on a single vendor and increasing availability [20].

IX. CONCLUSION AND RESEARCH IMPLICATIONS

In this paper, a cloud-based hall reservation and event management system called EventIQ has been proposed as a means of resolving conflicts in the scheduling of events and efficient utilization of resources in learning institutions . The effectiveness of the proposed system in resolving conflicts is ensured through server-side conflict detection, as opposed to traditional solutions [19].
The experimental results of the proposed system show its ability to improve the rate of successful bookings, latency, and reliability [10]. The proposed system offers a solid platform for the development of intelligent campus management solutions in the future

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