TED UNIVERSITY

CMPE491

Computer Engineering

Library Occupancy Detector

Project Analysis Document

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1. Introduction

The Library Occupancy Detector project aims to develop a computer vision system that can detect and monitor the occupancy of seats and tables within the TEDU library. Thanks to this system, students will be able to easily access the library's occupancy rate without going to the library. In addition, the library administration will be able to use the system's data to make various evaluations. In order to share this data about the occupancy rate with students, data will be made accessible from the school's existing applications or the portal.

2. Proposed System

2.1 Overview

The Library Occupancy Detector project aims to enhance privacy compliance while providing accurate occupancy information within the TEDU library. The system prioritizes privacy by considering students as objects in order not to contradict the KVKK, and no records of the cameras will be kept. Although the system considers students as objects, this will be different from other objects such as books, laptops, and coats. To achieve this, the system will detect tables, chairs, and objects with a minimum number of cameras placed at appropriate angles in the library.

In order to provide a more accurate assessment, the system will share occupancy information in two distinct ways: by indicating both the number of students present and the total space occupied by objects and students. Thus, it will allow students using the application to see the number of areas that are held with objects and have a "hold" status, separate from the current number of students. In accordance with the request of the library administration, which is the client of our project, the locations of the areas held with items that exceed a certain period of time will be shared with the students, and these areas will be made available by sharing the information that items can be removed from there.

2.2 Functional Requirements

2.2.1 REQ-1: Real-time Seat/Desk Occupancy Detection

In real time, the system must determine whether the tables and chairs in the library are occupied or not, using computer vision technology.

2.2.2 REQ-2: Occupancy Rate Calculation

The system shall calculate and display separately the overall occupancy rate, which includes all occupied areas in the library, and the occupancy rate based only on the number of students.

2.2.3 REQ-3: Detection of Unoccupied Areas

The system shall accurately identify empty chairs and desks in addition to occupied areas.

2.2.4 REQ-4: Item Detection

The system should be able to detect items left on tables or chairs to distinguish between occupied and unoccupied areas. Therefore, an area where a student has left their belongings to reserve a spot can be considered as being in a "hold" status.

2.2.5 REQ-5: Past Occupancy Rates

The system shall retrieve occupancy data from the database to provide information exclusively to library administrators, including past occupancy rates for analysis and reporting purposes.

2.2.6 REQ-6 Occupancy Alerts

The system shall automatically share the locations of areas held by items when the hold duration exceeds the specified limit, allowing library administrators to utilize these areas.

2.3 Non-Functional Requirements

2.3.1 REQ-1: Accuracy and Adaptability

The system must demonstrate a high level of accuracy in detecting seat, desk, and table occupancy within the library environment. It should provide students with reliable information regarding available seating areas and accurately distinguish between occupied and empty spaces. Additionally, the system must adapt to changing lighting conditions and effectively identify items placed on tables and chairs. This adaptability is necessary to ensure reliable and accurate occupancy detection in various environmental conditions.

2.3.2 REQ-2: Performance

The system should function rapidly and efficiently, processing and displaying occupancy data without significant delays. Furthermore, it must not require excessive computing power to support continuous operation of the detection system.

2.3.3 REQ-3: Privacy

The system will prioritize user privacy by anonymizing data, refraining from recording images, and avoiding the storage of personally identifiable information to comply with privacy regulations such as the KVKK. Additionally, individuals will be treated as objects to ensure compliance and minimize legal issues.

2.3.4 REQ-4: Security

The system must implement robust security measures to prevent data breaches and unauthorized access.

2.3.5 REQ-5: Scalability

The system must be scalable to allow for updates or expansions in the future without requiring a lot of reworks.

2.4 Pseudo Requirements

2.4.1 REQ-1: Compatibility

The system shall seamlessly integrate with the university's existing infrastructure and applications, eliminating the need for additional new applications.

2.4.2 REQ-2: Maintenance and Updates

The system should be sustainable, allowing for regular updates and improvements based on feedback from both students and library management.

2.4.3 REQ-3: Cost Efficiency

The system shall aim to be as economical as possible, achieving high performance with the fewest possible cameras to maximize effectiveness and stay within budgetary limits.

2.5 System Models

2.5.1 Scenarios

- Burak, a student at TEDU, wants to study in the library. Before heading there, he checks the real-time occupancy status on her phone using the TEDU App or myTEDUPortal. He sees that the library is currently at 70% occupancy, so he decides to go there knowing there are still plenty of seats available.

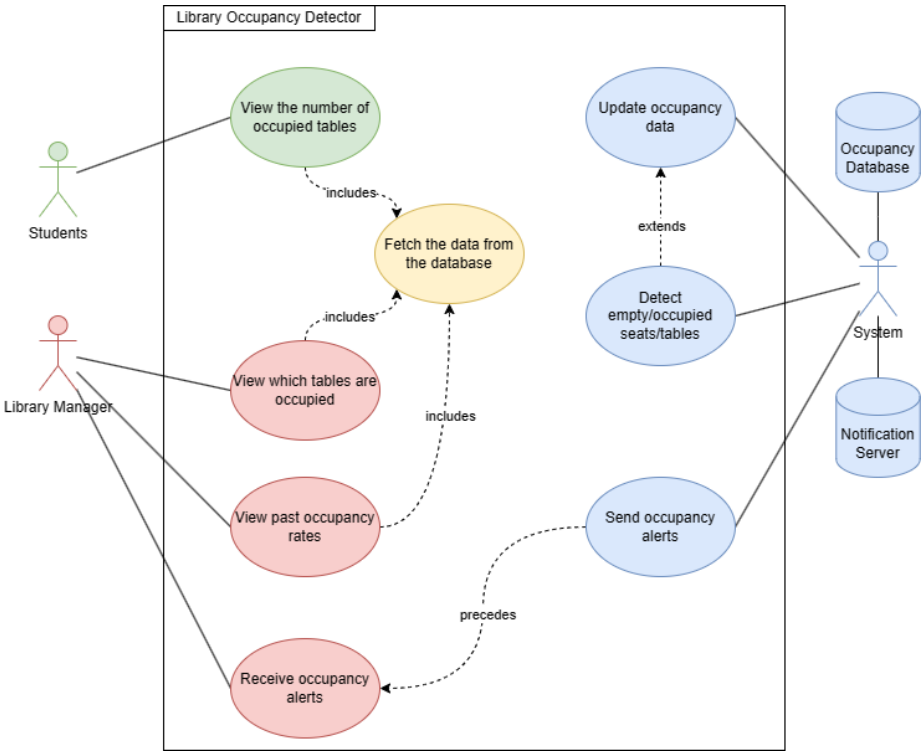
- Buse, the library manager, receives an alert on his computer notifying him that the library has reached 90% occupancy. He quickly decides to open up a study room that is usually kept closed to accommodate the overflow of students.

- Furkan leaves his laptop on a desk to occupy a seat in the library and leaves the library. The system detects the laptop left on the desk for some time and notifies the library staff, who then secures the laptop and empties the desk for some other student.

- It's exam week, and the library is experiencing a surge in student traffic. The system provides historical data to be analyzed by the library. The library manager adjusts the seating arrangements based on the data, ensuring maximum space utilization during peak hours.

- Burak plans to study in the library and decides to check the occupancy status using the library's app on his phone. Upon opening the app, Burak noticed that it was displaying an error message instead of the usual occupancy status. He tries refreshing the app multiple times but still encounters the same error. Burak decides to report the issue to the library manager. He sends an email to the library's support address, explaining the error he encountered and requesting assistance in resolving it.

2.5.2 Use Case Model



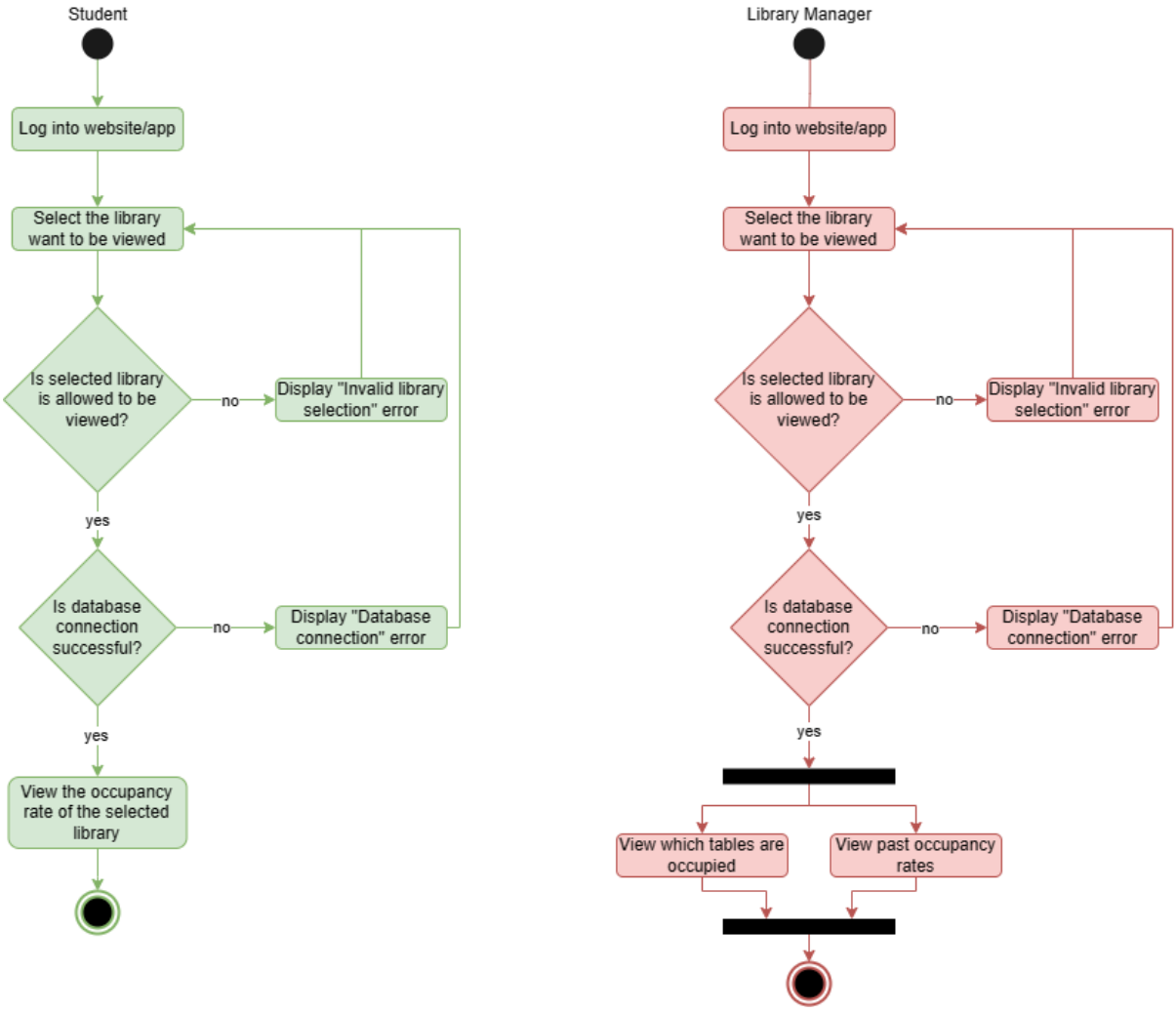
As the Use Case Diagram states, there are three main actors. They are students, the library manager, and the system. Students shall not access some parts of the systems as the library manager and the system shall provide necessary actions to give access to students and the library manager.

Students shall view the number of occupied tables in the selected library (library selection is more detailed on the activity diagram). This case requires fetching the data from the related database therefore, we used the “includes” relationship between them.

The library manager shall view which tables are occupied, and past occupancy rates and receive occupancy alerts. Viewing which tables are occupied and past occupancy rates requires fetching the data from the related database as in the case of students to state that, we used the “includes” relationship on the diagram. Receiving the occupancy alerts from the system shall wait for send occupancy alert case of the system so, we used the “precedes” relation between them.

The system shall detect the empty/occupied seats/tables and update the occupancy data on the database. If it detects that some chairs are occupied by leaving belongings on the table for some time, it should alert the library manager.

2.5.3 Dynamic Model

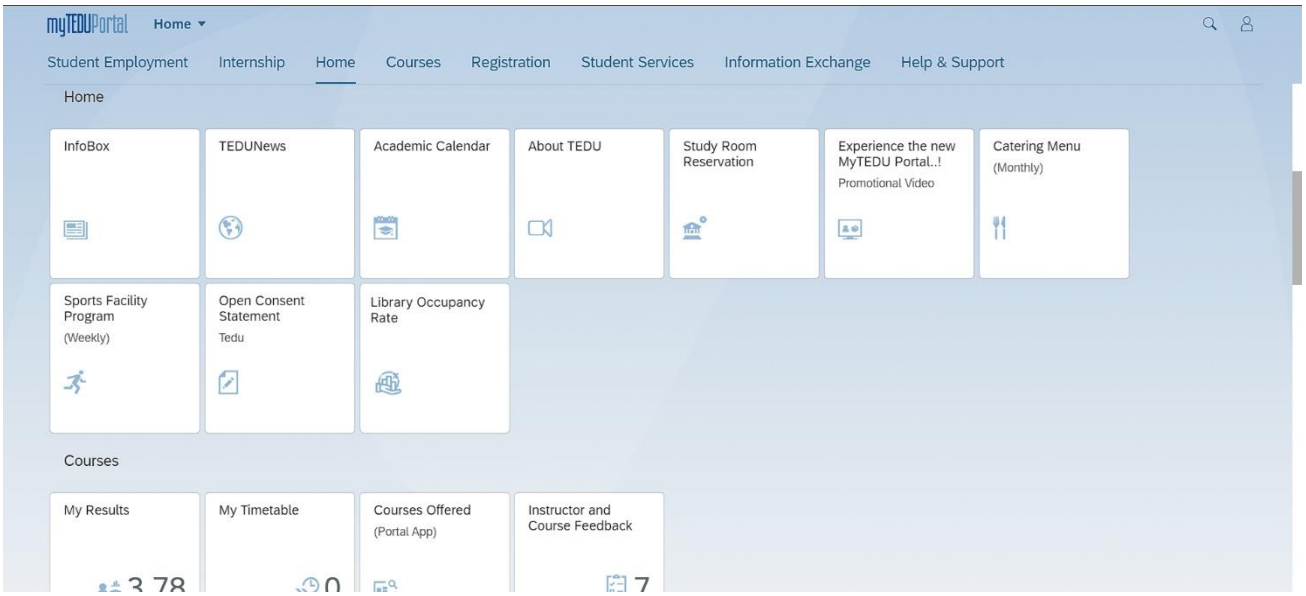


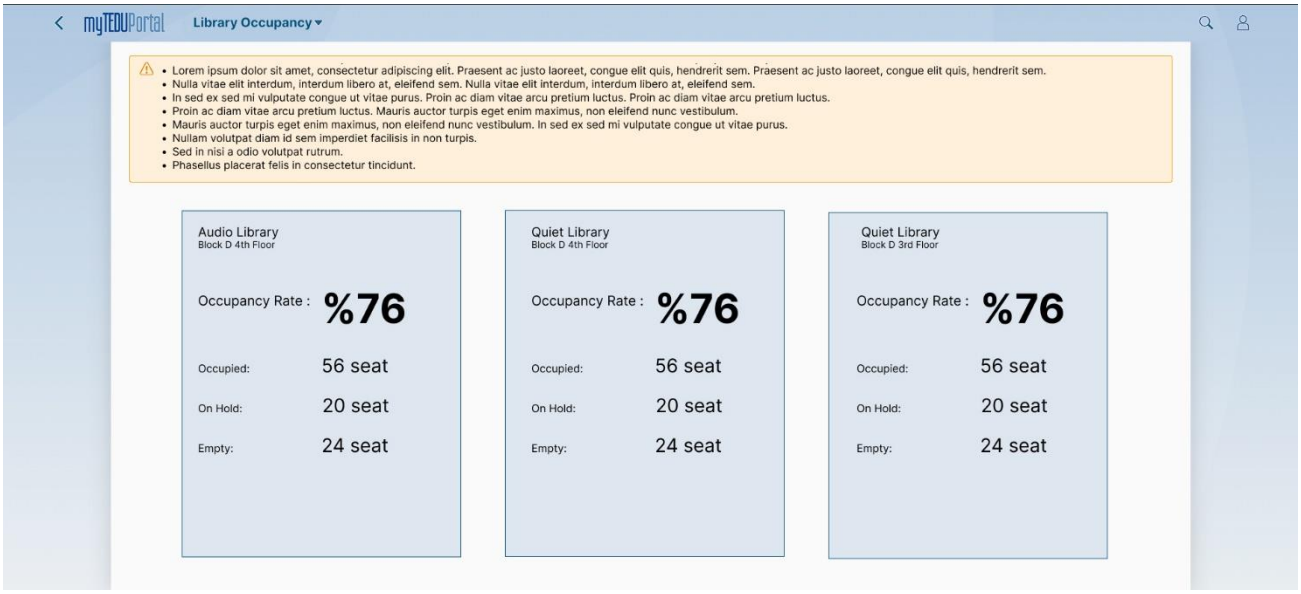
As the activity diagram suggests, there are two main scenarios and users for the system. Both the library manager and students pass through the same process until the viewing part. At that point, there are two additional actions that library managers can take because of their priority on the system.

Before viewing the occupancy rates, both users should select the library they want to view. If there occurs an error at that part, the system shall provide an error message stating the situation that causes the error and go back to the library selection part. The same process exists for database connection checks too.

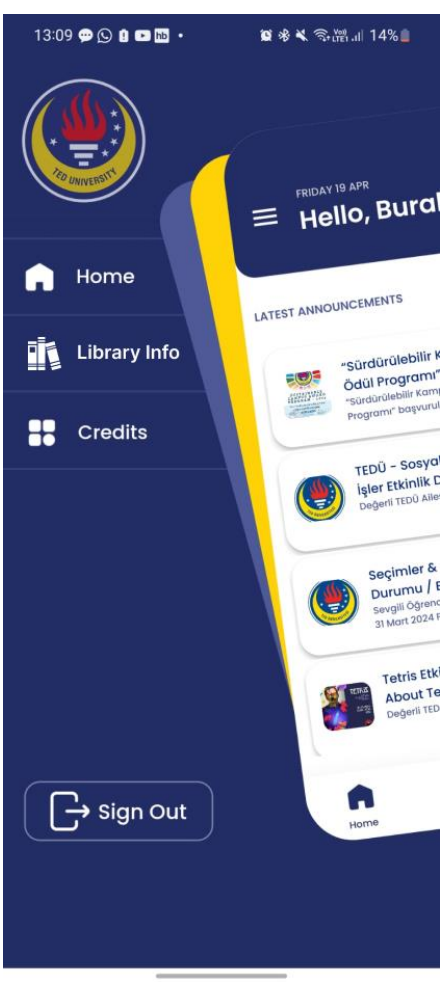
2.5.4 User Interfaces

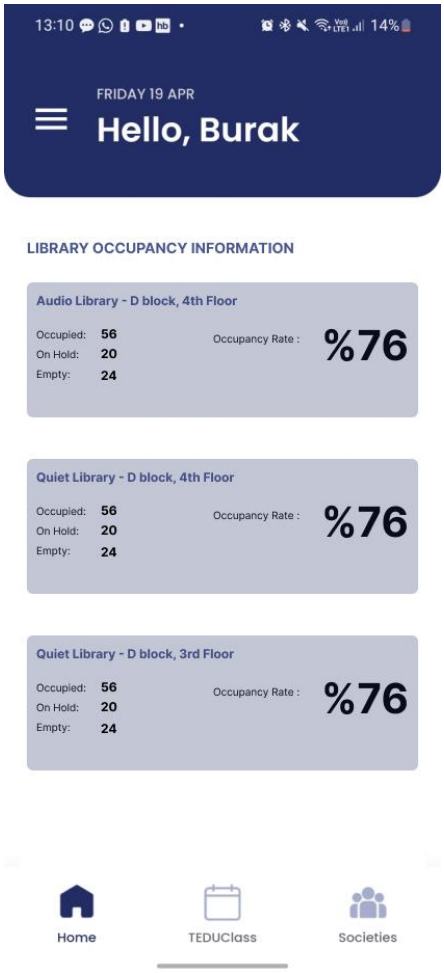
- **myTEDUPortal**





- **TeduAPP**





These designs are mockup designs made as extensions to existing applications.

3. Glossary

KVKK: Personal Data Protection Law, the Turkish legislation governing the protection of personal data, in accordance with Kişisel Verilerin Korunması Kanunu.

myTEDUPortal: The website where students, faculty, and staff can access academic and administrative services, such as course registration, grades, and schedules.

TeduAPP: The "Tedu App" is an application designed and developed by Tedu students, aiming to guide students about school activities, class schedules, and communities within the school under the slogan of "by students, for students.

4. References

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