**Proposal for SmartLib, an Intelligent Library Seat Management System**

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**Executive Summary**

Have you ever experienced walking around the library aimlessly looking for an empty seat, just to discover that most of them are taken, and many of the empty seats hogged by the belongings of others? Fret not, SmartLib will be developed just to address this issue that many of us are facing on a regular basis.

SmartLib is an intelligent system aimed to improve the experience at the libraries across Nanyang Technological University. Its main purpose is to address the issue of locating empty seats/booths at the libraries as well as mitigating seat hogging. SmartLib is a system that enables library users, mainly students, to check the current capacity of the library seats. They will also be able to view the availability of individual seats in the library. In addition, users will be able to reserve a seat at the library for a short period of time before walking over to the library, to ensure they can secure a seat to avoid unnecessary disappointment.

To mitigate seat hogging, any seats that are being hogged will be flagged out to the on-duty library staff, if users are away for a set period of time. Appropriate actions can then be taken, such as issuing warnings or confiscation of belongings to free up the seat to other users.

Focusing on user experience and ease of use, SmartLib will be designed with the end users in mind. It will provide a convenient way for users to check the capacity of the library, and also a fuzz free method of reserving the seat when on the way to the library. With a click of a button, users will be able to have an overview of the current capacity, as well as a user-friendly map interface of the library.

SmartLib is a versatile system with a Web interface, which can be deployed at many locations. Some of the examples are personal mobile devices and computers of the users, strategically placed kiosks at the library, as well as workstations of the library staff.

Here at Team Xeon, we are eager to present this innovative solution to you. We are a team of developers dedicated to working on this project. The team, consisting of various management and development roles, will work together with a common goal - To deliver the project within the planned timeline and budget, with utmost quality in mind.

**Statement of Problem**

In Singapore, public libraries have been developed to steer away book repositories and quiet sanctuaries to become a crucial common space in society, said S. Iswaran, Minister for Communications and Information, in 2020. [1] Common spaces such as seats and booths in the library accommodates to the people from all walks of life, such as students studying, the elderly reading the newspaper or parents bringing their kids to encourage reading.

With an increasing percentage of the population now going to universities, it only meant that there will be a decreasing amount of common space available to students at the university. Especially in the libraries, study and reading spaces such as common seats and tables and individual booths are getting crowded, and it is becoming a norm that people are fighting to get the best seats as soon as the library opens . [2]

Especially during examination period, a trip to the library is likely to elevate the students’ stress, as they face difficulties in searching for a vacant seat to do their revision for the examinations. Moreover, they will be wasting time looking for a vacant seat, instead of using the time for studying. [2]

Without a proper seat management system in place, the libraries at Nanyang Technological University have been plagued with many issues such as seat hogging, as well as the uncertainties and frustrations faced when looking for a vacant seat.

A survey conducted with over 500 users who frequent the libraries at NTU revealed that over 85% of them often have difficulties locating vacant seats in the library, with around 80% stating that they often spend more than 5 minutes in the library to locate a vacant seat.

In addition, seat hogging is a prevalent issue in the library, where users leave their belongings at the seat and leave for a long period of time, thus depriving other users of vacant seats. The conducted survey also revealed that over 70% of them have witnessed seat hogging in the library, and the top reason for doing so is to have their meals and to attend classes.

**Objectives**

The document proposes a library seat reservation system using human detection. This system will be an Internet Of Things system with a web interface. Cameras will be placed around the library to detect if the seats are occupied and send the information to the database through the internet.

The target audience for this system will be mainly students and the librarians. The students will interact with the web interface to obtain the latest information about the occupancy of library seats and reserve seats. The web interface will alert the librarian if the seat is left unattended.

The design objective are listed as:

1. Seat occupancy detection using camera
2. Connectivity of camera devices
3. Check availability of seats,
4. Reserve a seat, and
5. Alert the librarian
6. Data analysis

The system must be able to read the camera image with a resolution of 1280 x 720 pixels. The system must be able to detect humans from the camera image with an accuracy of 90%. The system will use human detection to determine if a seat is currently occupied.

The system must be able to connect up to 20 cameras, the cameras must be able to transfer information to the system through the internet.

The user or librarian must be able to identify all the available seats in the library within 10 seconds of seeing the graphic interface. The available seats will be marked in green while the occupied seat will be marked in red.

First time users must be able to reserve a seat within 30 seconds. The user must be able to reserve a seat by clicking on the available seat.

The system must be able to identify seats that are left unattended for more than 60 minutes by the user from the camera image with an accuracy of 90%. The system will alert the librarian to clear the seat for other users.

**Technical Approach**

To achieve the objective as stated, the approach is broken down into customer needs, target specifications, technology consideration and system architecture/platform.

**Customer Needs**

1. Students need a way to view the number of available slots and book the slots in the library using either a website or an application. It will save time for users looking for empty seats in the library and can view and compare the numbers of available slots in different libraries so that they do not need to travel from one library to another.

2. Students need a product to show the state of each seat and its location clearly. Once students enter the website, they will be able to quickly view all available seats and their locations clearly so that they can easily locate their preferred seat and for seat booking. The seat location should also be designated on a map so that users can choose their preferred seat location.

3. Many students are reported to be complaining about the seat hogging issue in the library. A system is needed to alert the librarians to take necessary actions against the seat hoggers.

4. The librarians need an admin account which has more functionalities than the student account. The admin account is able to modify seats, receive alerts and generate occupancy reports for the library. When there is a seat left unattended for more than 60 minutes, the system will alert the librarian to take necessary action. Besides, librarians need to add, remove and temporarily grey out seats in the library. Lastly, the librarians need to generate an occupancy report for the library every month.

5. Need to ensure librarians and students are able to log-in to admin and student accounts respectively. The website also needs to prevent one user from booking multiple seats.

6. Users need the website to be accessible from any devices including smartphones, tablets, laptops, kiosks and workstations. Users of the product consist of students who are looking for empty seats and librarians who manage the system. Students mainly bring their phones, tablets, and laptops to the university, and they may also use kiosks in the library to make their booking. Besides, librarians use workstations to control and manage the system.

**Target Specifications**

1. The website should allow users to book their desired location in advance.

2. The seats’ state and locations should be easily accessible by users, and the locations of the seats on a map should be shown on the website. The seats should be marked in different colours for different availability states so that the users can choose their desired seats. The total number of available seats in the library should be shown.

3. To solve the issue of seat hogging, the system should remind the librarians to take necessary actions to free up the seat for others.

4. Admin account has to be created for the librarian. For the admin account, there should be functions such as alerts for seats which have been hogged for more than 60 minutes, and functions to add, remove and temporarily grey out seats in the library. Librarians should also be able to generate seat occupancy reports for the library.

5. A user login system should be used on the website. Students and librarians should be able to sign in into students and admin accounts respectively.

6. To make the web page accessible from browsers on smartphones, tablets, laptops, and workstations, the website should be designed separately for mobile devices and PCs, or the website should be able to automatically adjust the page width by detecting the browsing device.

**Technology Consideration**

To ensure an effective system, a number of applicable technology is required, The technologies are Human Detection, Firebase, Internet Of Things, React JS, Machine learning and WiFi Camera

|  |  |
| --- | --- |
| Technology | Remarks |
| Human Detection | Using deep learning model to determine if a person is present in a particular environment |
| Firebase | Realtime database in a cloud-hosted NoSQL to store different seat information |
| Internet Of Things | System of interrelated camera devices with the ability to transfer information over a network |
| React JS | JavaScript library for building the user interfaces for the system |
| Machine Learning | Method of data analysis to identify patterns or classification |
| WiFi Camera | Camera with the ability to transmit its video feed over a network |

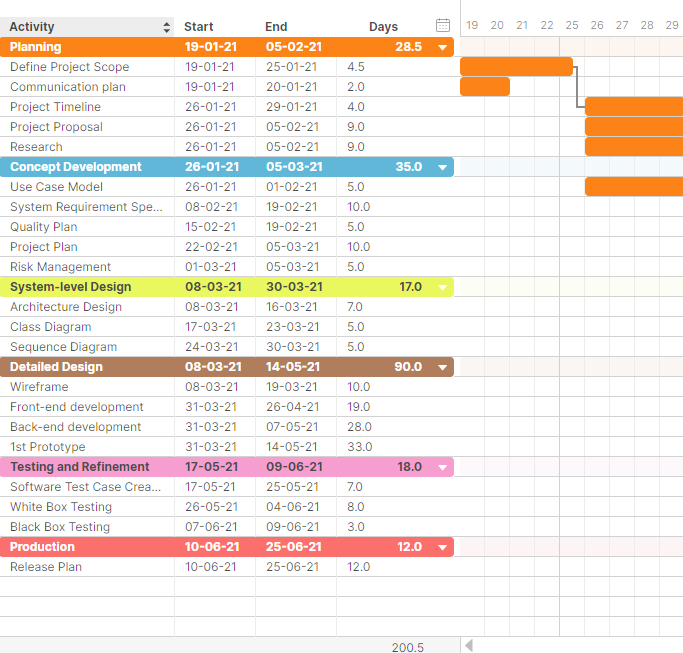
**System Architecture/Platform**

Development tools are used to aid in the project development consistency and effectiveness. GitHub is a code hosting platform used for version control, this will allow development to happen simultaneously and to manage changes in the software code. Visual code is a code editor to the development operations such as debugging or task running.

The system uses the 5 Layer Architecture of IOT, the five layer consists of Perception layer, Network layer, Middleware layer, Application layer and Business layer. The perception layer consists of the WiFi camera which is used to gather information regarding the environment. The Network layer is the connecting layer between the perception and Middleware. It gets the information from the perception layer and passes the information to the Middleware layer through networking technology such as WiFi. The Middleware layer will do image processing and identify occupied and unoccupied seats and store the data. The Application layer manages all the application processes based on the information stored. Applications such as alerting the librarian , displaying the available seats and allowing users to interact with the system. The business layer will analyse the information of the number of users and occupancy rate and generate a report for the librarian.

**Project Management**

Team Xeon will be implementing Waterfall project management in this project. The project will be divided into 6 phases which are Planning, Concept Development, System-Level Design, Detailed Design, Testing and Refinement and Production and the phases will be carried out sequentially. The project timeline for this project is as shown in figure 1. Due to the short timeline, the team has to stick to the tight deadline that is planned during the planning stage. The team will spend more time in the planning stage and as any modification in the later stage will cause the project to return to stage 1. This will reduce the risk of the team of failing to deliver the project before the deadline. The duration of this project will last for 6 months starting from 18th of January 2021 to 25th June 2021.



**Figure 1:** Gantt chart for the project. The solid bars indicate the portions of the tasks that we have accomplished.

Each person in Team Xeon will take up 1 to 2 roles and their job scope of each role is well defined before the team begins the project. The team also agreed on several communication platforms for the discussion of the project.

**Team Structure**

The following is the list of executive roles.

• Project Manager - Kenny Voo

• Lead Developer - Wilson Tai

• Front End - Irsyad, Hou Jing

• Back End - Zeyu

• QA Manager - Kenny

• QA Engineer - Wilson Tai

• Release Engineer - Hou Jing

**Roles and Responsibilities**

**Project Manager: Kenny Voo**

• Oversees project progress

• Approves and executes project plan

• Assigns tasks and reports status of project to team members

• Manages and motivates team members

• Represents the team to the outside world

**Lead Developer: Wilson Tai**

• Overall Technical Lead

• Responsible for Product Release

• Coordinate team’s schedule

• Ensure Effective Communication between team members

**Front End Developer: Irsyad, Hou Jing**

• Implement the visual elements of the final product

• Ensure the technical feasibility of the UI/UX designs

• Optimize application for maximum speed and scalability

• Assure all user input is validated before sending it to the backend

**Back-End Developer: Zeyu**

• Responsible for Server-side application logic

• Integrate their work with the front-end side

• Design and implementation of data storage solution

**QA Manager: Boon Shuan**

• Oversee the overall product and process quality

• Recording, analysing and distributing statistical information

• Supervising QA engineer

**QA Engineer: Wilson Tai**

• Reviewing quality specifications and technical design documents to provide timely and meaningful feedback

• Create detailed and comprehensive test-cases

• Coordinating quality test activities

**Release Engineer: Boon Shuan**

• Create baselines, build and integrate changes for delivery

• Manage release of product

• Maintain and monitor software builds

**Team Communication**

Team Xeon communication channels are as followed:

• Weekly online meetings (Zoom)

• Whatsapp group

• Collaborative workspace (Asana)

**Deliverables**

|  |  |  |
| --- | --- | --- |
| **Deliverables** | **Estimated Completion Date** | **Final Dateline** |
| Project Proposal | 30th January 2021 | 2nd February 2021 |
| Use Case Model | 30th January 2021 | 2nd February 2021 |
| System Requirement Specification | 13th February 2021 | 16th February 2021 |
| Quality Plan | 14th February 2021 | 16th February 2021 |
| Project Plan | 27th February 2021 | 2nd March 2021 |
| Risk Management | 27th February 2021 | 2nd March 2021 |
| Prototype Demo | 27th February 2021 | 2nd March 2021 |
| Prototype related items; Code, documents, Powerpoint Slides or Video Clips | 27th February 2021 | 2nd March 2021 |
| Design Report on Software Maintainability | 4th April 2021 | 6th April 2021 |
| Configuration Management Plan | 4th April 2021 | 6th April 2021 |
| Change Management Plan | 4th April 2021 | 6th April 2021 |
| Release Plan | 4th April 2021 | 6th April 2021 |
| Presentation Slides (Project Introduction and Summary) | 4th April 2021 | 6th April 2021 |
| Test Plan | 4th April 2021 | 6th April 2021 |
| Test Cases and Requirements Test Coverage Report | 4th April 2021 | 6th April 2021 |
| CMMI Level 2 Definition | 4th April 2021 | 6th April 2021 |

Requirement Specifications

WiFi/Surveillance Camera

* It must be able to capture an image every 3 seconds and send it to the SmartLib for post-processing.
* Each camera has to be able to cover about 10m square foot area positioned to cover different sections of the seating area at each level of the library.

Backend System

* The system must be able to receive the images from the wifi surveillance camera via Wifi signal.
* The human detection software must detect any human form occupying each seat from the images and update the database accordingly(On which seats are occupied and which aren’t)
* The human detection software must be able to differentiate between human forms and other objects.
* The system must send an alert to the librarian interface if an object is occupying a seat/table for more than 1 hour.
* The system must be able to communicate with the application database and provide the necessary feedback mentioned earlier.
* The system must be able to manage user bookings and modify the individual seat occupancy status accordingly.

User/Librarian Interface (Web Application)

* It must allow users to log-in to 2 types of user account (Student/Librarian Access) via the user input.
* It must allow users to enter their account details to log into their accounts.
* It must allow the user to be able to view the occupancy status of each seat at every level of the library.
* It must be able to display the different levels of occupancy status of each seat; Red for Occupied, Orange for reserved and Green for Unoccupied according to the feedback received from the backend system.
* The user must be able to view the seats in its original layout in real life and toggle through the different levels of the library.
* It must be able to provide live updates of the occupancy status of each seat.
* The application must allow the user to book an unoccupied seat.
* The application must be able to cancel a booked seat automatically if the seat was left unoccupied for more than 15 mins.
* In the librarian interface, the librarian must be allowed to overwrite the occupancy status of each seat in the library (Eg. As part of Covid-19 rules of safe distancing)

Non-Functional Requirements

## Performance Requirements

1. System must be able to refresh the live occupancy status of each seat at a rate of 1s.
2. System must accept user seat bookings within 10ms.
3. System must be able to handle 200 user requests per second.
4. System must not crash or return errors during the use of the application

## Safety/Security Requirements

1. System must not allow students to create/have access to a librarian account and its user interface.
2. System must be able to keep different user account separate (No cross booking)

### Usability

1. System must be intuitive. Users should be able to navigate through the interface with a minimal number of steps.
2. The user interface has to be bold and informative so users can pick up easily when using it.

### Reliability

1. The system should display data accurately.
2. The system should be fully functional after the application has been restarted (During maintenance session for an instance).

### Availability

1. The system should be responsive at all times except for scheduled maintenance periods which would happen when the library is closed..

### Supportability

1. The application should be able to run on all platforms via a website so users can access it via a mobile device or a computer capable of connecting to the internet.

Scalability

1. The servers and backend system must be scalable to allow future expansion of this system in other libraries/food courts.

Test Procedures

* Black Box Testing
  + Equivalence Testing (Testing the boundary values of the human detection system to make sure it detects the seat area only and nothing else)
* White Box Testing
  + Control-Flow Testing

**Budget**

In this section, we have collated the necessary cost that will be incurred by this project. In order to deliver a high quality project, we have carefully selected a range of both hardware and software to meet our functional requirements. It is also important to keep the people working on this project feeling motivated and provide a conducive environment for them to meet the project schedules.

The total estimated cost of the whole project is amounted to **$132,780** with the breakdown given below:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Item** | **Supplier** | **Quantity** | **Unit Price** | **Monthly Cost** | **Cost through whole project lifespan**  **(6 months)** | | **Hardware** |  |  |  |  |  | | Computers | Dell | 5 | $1,000.00 |  | $5,000.00 | | WiFi Camera | D-Link | 20 | $119.00 |  | $2,380.00 | | Office Rental | NTU | 1 | $650.00 | $650.00 | $3,900.00 | | **Software** |  |  |  |  |  | | Database | FireBase | 1 | $250 | $250 | $1,500.00 | | **Human Resource** |  |  |  |  |  | | Project Manager | - | 1 | $5,000.00 | $5,000.00 | $30,000.00 | | Project Team Member | - | 5 | $3,000.00 | $15,000.00 | $90,000.00 | | **Total Cost** |  |  |  | **$20,900.00** | **$132,780.00** | | | | | |

**Communication and Coordination with Sponsor**

Main communications and coordination with our sponsor will be done through email, using corporate emails, as it will be the most formal type of communication and it also acts as a formal record of all communicated information and coordination.

There will also be online teleconference meetings with our sponsor once every month for progress updates and discussion of any issues that may arise during the span of the project. At the later stages of the project, the meetings also act as a channel for us to showcase the project prototype and demonstrations.

**Team Qualifications**

Team Xeon is a dedicated team of professionals with adequate skill sets to successfully develop this project with quality. You may refer to the resume of each team member located at Appendix A of this document.

Kenny has 3 years of experience in leading projects in several hackathons and overseas competitions. Besides, he was in charge of the vision subsystem of a project during his internship at ROS-I in ARTC. He completed the past projects on time and in good quality. He is chosen by the team to oversee the project to ensure the desired outcome is accomplished.

Wilson participated in a lot of hackathons and he is a founder of “ Help Lah Solutions ”. He is currently involved in completing a project for a company. Moreover, he will explore different technologies and take up different projects during free time. He has a lot of hard skills which he can guide the team to solve the problem with technology.

Hou Jing has interned in various companies such as A\*Star. He was the full stack developer at SEA group for 6 months and received good feedback from his supervisor. His supervisor described him as a meticulous and responsible individual. He also has experience in software releases during his internship.

Irsyad has experienced a lot during his time as a research assistant at the Data Storage institute. During his time there, he was commended by his supervisor for delivering high quality research material and was well documented. His persistence in gathering data and experimenting with new technological material will aid in bringing this project forward.

Zeyu has strong interest in cloud and databases since secondary school. He took the extra steps to learn the knowledge. In the end, he managed to land his dream internship as a backend developer for Amazon. During that time, he developed his skills about databases and completed his work in high quality. With his experience, he will manage to solve any database problem in this project.

**Conclusion**

With the booming increase in the usage of intelligent systems and digital interconnectivity in our lives, SmartLib is an essential addition to the many services available within the university, which will alleviate the existing seat management issues in the library.

**References**

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**Appendix A:**

**Résumés of Team Members**

The following pages present one-page résumés of the team members for this project.

