The Campus Hub

Software Requirement Specification

2021.10.24.

Introduction to Software Engineering

2021fall_41_TEAM13

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1. Preface

1.1. Objective

In this chapter, we define the expected readership of this document and describe its structure and version history. Document history shows a rationale for the creation of a new version and a summary of the changes made in each version done by each team member.

1.2. Readership

Team 13 designs and implements the functions of the Campus hub service according to this specification. Then, team members of Team 13, professors, and TAs in the Introduction to Software Engineering class are expected be the main readers. Furthermore, students or staff related to Sungkyunkwan University who have access to this system can also become readers.

1.2.1. User

The expected reader of user requirements is users of the system. Therefore, from the user's point of view, we explain the requirements in an easy-to-understand manner, refraining from using technical terms and rather using visual materials such as diagrams with the description in natural language..

1.2.2. System

System requirements are a structured language expression of system functions and constraints. It shall be written systematically so that it can be used as a reference material during the development process for developers or used in contracts with customers. Therefore, this is mainly for developers, Team 13 members.

1.3. Document Structure

Before starting each chapter describing our system, we introduce what each chapter covers in this chapter.

1.3.1. Introduction

This chapter mainly includes the purpose of this project and the need for the system. The overview, glossary including what terminology we use, some acronyms and abbreviations of this report, and references we have been used for this requirement specification regarding our system are also described in this chapter.

1.3.2. Overall Description

This chapter includes overall description of our system. Here, interfaces in various aspects are described in product perspective. Then, we describe main functions of this product in high-level and characteristics of users in terms of system administrators and general users. Finally, constraints, assumption and dependencies to go through with this product are described.

1.3.3. Specific Requirements

We describe requirements in various perspectives such as functional, nonfunctional and so on in details to show the needs of this system in this chapter. Finally, we organize all requirements in forms of graphical way (e.g. diagram) to understand not only each individual requirement but also the requirements as a whole.

1.3.4. System Evolution

In this chapter, we describe the fundamental assumption on which the system is based on, and any possible changes due to hardware evolution, changing user needs and so on. Through this, discuss the direction to evolve according to the changes that may occur when the system is modified, and remove the possibility for incidental design changes that can be constrained. Ultimately, it is possible to reduce the cost of modification and the burden on system designers.

1.3.5. Index

In this chapter, you can check all tables and figures used to describe the product at a glance.

1.4. Document History

[Table 1] Document History

Date	Version	Description	Writer
2021/10/08	0.1	Style and overview	Na-Hyeon-Oh
2021/10/17	1.1	Add contents of 3.4 ~ 3.5	Ngzhiwei
2021/10/23	1.2	Add contents of 3.2	Jeong-Ah-Lee
2021/10/23	1.3	Add contents of 3.3	So-Hee-Yun
2021/10/24	1.4	Add contents of 5	Jong-Won-Heo
2021/10/24	1.5	Add contents of 3.1	Gang-Min-Lee Sang-Min-Han
2021/10/24	1.6	Assemble and organize	Na-Hyeon-Oh
2021/10/25	1.6.1	Reflect feedback (Standardize terminologies)	Na-Hyeon-Oh So-Hee-Yun
2021/10/28	1.6.2	Reflect feedback of 3.2	Jeong-Ah-Lee
2021/10/28	2.0	Add contents of 4.5.1 ~ 4.5.2	So-Hee-Yun
2021/10/28	2.1	Add contents of 4.1.2 ~ 4.1.4	Na-Hyeon-Oh
2021/10/28	2.2	Add contents of 4.1.1	Jeong-Ah-Lee
2021/10/29	2.3	Add contents of 4.6 ~ 4.7	Jong-Won-Heo
2021/10/29	2.4	Add contents of 4.2.3 ~ 4.2.4	Ngzhiwei
2021/10/29	2.4.2	Reflect feedback of 4.1.1	Jeong-Ah-Lee
2021/10/29	2.5	Add contents of 4.2 ~ 4.3, 4.5.3	Gang-Min-Lee
2021/10/29	2.6	Add contents of 2.2 ~ 2.3	Ngzhiwei
2021/10/30	2.7	Add contents of 4.2.1 ~ 4.2.2	Sang-Min-Han
2021/10/29	2.8	Reflect feedback and assemble Add contents of 1	Na-Hyeon-Oh
2021/10/30	2.8.1	Reflect feedback	Gang-Min-Lee Ngzhiwei
2021/10/31	2.9	Add contents of 1, 2.4 and organize	Na-Hyeon-Oh

2. Introduction

2.1. Objective

This document is a Software Requirements Specification (SRS) for providing The Campus Hub. This system is designed and implemented by Team 13 of the Introduction to Software Engineering at Sungkyunkwan University. The requirements for this are summarized, analyzed, and the system is designed and implemented based on the contents described in this document.

2.2. Purpose

The purpose of this document is to outline and publish the requirement specification for our smart campus in Metaverse, the Campus Hub. Unlike many other existing virtual smart campuses out in the current market, the Campus Hub is at a whole new level when it comes to creating a unique and seemingly-real campus life for our students and professors. Especially during this period where schools, students, and teaching and non-teaching staff struggle to the changes in the post-pandemic approaches, the Campus Hub compensates and provides an alternative solution to the issues. Academically, the Campus Hub has virtual classrooms which will not only improve learning but more importantly, regain the level of comfort and convenience for teaching, learning, and interactions between students and professors. Apart from the academic side, non-academically, the Campus Hub has an exhibition hall, library, and hub in which each offers a new spectrum of learning, expanding non-academically horizons, and having fun.

2.3. Overview

The remainder of this software requirement specification document includes three chapters and indexes. The 3rd chapter provides a bird's eye view of the Campus Hub, including its system interfaces, user interfaces, hardware interfaces, and more. Also, it includes brief descriptions of the Campus Hub's functionalities. Furthermore, the chapter ends with some constraints which need to be adhered to and some assumptions and

dependencies which need its equal considerations. In the 4th chapter, this document dives deeper into looking at the specific requirements, hardware and software interfaces and communication interfaces. Also, to provide a better understanding on the functional requirements, use case diagram, entity relationship diagram, and data flow diagram were put together to aid in the understanding of the Campus Hub from a diagrammatic perspective. Nonfunctional requirements, not described in the 3rd chapter, are described in this chapter. Last but not least, the 5th and final chapter talks about the system evolution. It provides a brief yet much-considered overview on the limitations and assumptions the Campus Hub may potentially face, and also, provides information on the evolution of hardware and change of user requirements.

All members contributed equally to the production of this document and we sincerely hope that you, the reader, can garner a better understanding of The Campus Hub through this document.

2.4. Glossary

The following table explains the acronyms and abbreviations used in this document.

[Table 2] Table of acronyms and abbreviations

Acronyms& Abbreviations	Explanation
VR	Virtual Reality
PC	Personal Computer
RAM	Random Access Memory
CPU	Central Processing Unit
HTTP	Hypertext Transfer Protocol
API	Application Programming Interface
OS	Operating System
UI	User Interface
URL	Uniform Resource Locator (web address)
GPU	Graphics Processing Unit

The following table defines certain technical terms used in this document.

[Table 3] Table of terms and definitions

Terms	Definitions
Space	Each place where the system is provided as Metaverse (e.g. Hub, Classroom, Library, Exhibition hall) and its internal places
Campus hub	What we are planning to make as Metaverse
Hub	The core-place where connecting all other places such as classroom, library and exhibition hall
Classroom	Available space that can be visited from hub for lecture and regarding activities
Library	Available space that can be visited from hub for services we can use in campus library
Exhibition hall	Available space that can be visited from hub for exhibition
Office hour zone	The place using classroom when student(s) make appointment with professor then freely question or talk about class or something else
User	Someone who uses the system such as college students and professor
System administrator	Someone who is well aware of the ultimate goals and directions of service provision and can meet them while managing the system
Server	A computer or computer program which manages access to a centralized resource or service in a network
Software	The programs and other operating information used by a computer
Network	For connecting devices together so that they can share information. In this system, it usually means internet

2.5. References

- Team 4. "Software Requirement Specification". SKKU, Last Modified: Jun. 7, 2019. https://github.com/skkuse/2019spring_41class_team5/blob/master/docs/requirement.pdf

- IEEE Std 830-1998 IEEE Recommended Practice for Software Requirements Specifications, In IEEEXplore Digital Library
http://ieeexplore.ieee.org/Xplore/guesthome.jsp

3. Overall Description

3.1. Product Perspective

This product is designed for professor and students. This service will improve not only "un-tact campus life" but also "discomfort of offline environment". The Campus Hub is divided by four sections as Hub, Classroom, Library and Exhibition hall and it supports the convenience of space movement among each section. Hub is a concourse where users can meet colleague, friends, senior and so on without face-to-face. Classroom, Library and Exhibition hall support services suitable for the un-tact era.

3.1.1. System Interfaces

- Each places are implemented by VRChat. UI/UX design and 3D modeling are implemented by Photoshop and Blender.

- Detail facilities such as space movement, upload projects for exhibition and camera angle for classroom are implemented by Unity2019.

- Since VRChat cannot communicate with out, we would use Youtube for uploading database of users.

3.1.2. User Interfaces

- An interface is provided through the screen of monitor of laptop or desktop, keyboard and mouse. The action of user's character occurs when press keyboard button or click mouse.

- User should send their data to server for using on the internet not in the system.

3.1.3. Hardware Interfaces

The system is operated in PC. The PC must have at least Intel i5-4590 CPU or AMD FX 8350, 4GB RAM and graphic card with NVIDIA GeForce® GTX 970 or AMD Radeon™ R9 290 or Intel UHD Graphics 610.

3.1.4. Software Interfaces

The system is intended for Windows 10.

3.1.5. Communications Interfaces

User and server communicate with HTTP protocol. The server and VRChat communicate with video from Youtube.

3.1.6. Memory Constraints

The system should run on PC with least 1GB RAM for primary memory.

3.2. Product Functions

3.2.1. Register & Login

Users need to download our application and sign up for the system. On the login page, there is a button for registration. The user must select whether he is a professor or a student. After entering information in required fields such as name, school, and department, the user can register to the system. Users can also register using email or steam accounts. After the user registered to the system, the user can log in and use the system.

3.2.2. Avatar Settings

After registration, users can decorate their avatars as they want. Users can set hairstyles, clothes, accessories, facial expressions, etc.

3.2.3. Profile

On the profile page, users can view the basic information they entered when signing up, and they can also edit this information. In profile, the user can register the class schedule. According to the specified class timetable, the user is automatically moved to the corresponding classroom, and this is reflected in the attendance check.

3.2.4. Space Movement

Users can freely move between Hub, Classroom, Library, and Exhibition hall. A list of spaces except for the current space is displayed, and the user can move by clicking on the list bar where the space is written.

3.2.5. Chatting

Users can chat and talk with other users in any space. If the user wants to chat with another user, double-click the user and click the Chat button. A user who receives a chatting request from another user can accept or decline the chat. Users can select public or private chat.

3.2.6. Visit Hub

When users log in to the system, they come to the Hub. Users can play games such as chess and billiards or watch a movie in the entertainment space of Hub. Users can also rest on a beanbag.

3.2.7. Visit Classroom and Office Hour Zone

- Student users can consult with professors in the office hour zone. Users can make a reservation in advance as a group or individual, and the user's ID will be checked upon entry. If there is no reservation, the user can enter, and if there is a reservation, "in conversation" will be displayed on the door and the user will not be able to enter. In the career counseling room, users can share files such as resumes and documents.

- When the class starts, the student users automatically enter the Classroom, and this is reflected in the attendance check. Student users cannot leave the room until the end of the class. If a student user has a question, they must press a button on their desk during class. If the professor approves, the student user can ask questions. Alternatively, student users can post their questions on the anonymous question board. Students users who are seated at a distance can watch a screen projected through a camera placed in front of the classroom.

- Professor users can consult with students and can conduct lectures in the classroom. When a student indicates that they have a question by pressing a button on the desk, they can also allow it to be answered.

- Student users can use the classroom's bookshelf. Users can enter and check the name of the textbook for the subject, and they can receive book recommendations related to the textbook based on the library e-book material.

3.2.8. Visit Library

- Users can access the library through their ID card. After entering, you can use the elevator to move to the 1st, 2nd, and 3rd floors. Books can be borrowed on the first floor. The bookshelves are divided by field. After selecting the desired field, the user can check the list of books. The user can return the borrowed book by clicking the book on the user's personal screen. Also, in the posting space on the first floor, users can post promotional materials.

- The reading room is available on the 2nd floor. Users can register by clicking an empty seat and entering their ID. After entering the ID, the study time of users is automatically recorded. If the user moves to another space, seat registration is automatically canceled and a window showing the total study time appears. A ranking service is provided based on a timer function that automatically measures study time. Users can check their average study time and ranking.

- Study rooms are available on the 3rd floor. When the user enters the 3rd floor, a full list of study rooms and a list of currently available rooms are displayed. Users can use the study room after entering the IDs of all the people who will use the study room. Other than the reserved number of users who cannot use it. In the study room, users can use the blackboard that everyone in the study room can view, and they can discuss in the form of chat or voice.

3.2.9. Visit Exhibition hall

- The exhibition hall is a space that can be used for exhibitions in art and photography clubs or graduation works exhibitions. In the case of artworks, experiential exhibitions are possible. When the user goes in front of the work, the lighting or song that matches the work changes. Also, the size of the work may change or the image may move as if inside the work. When the user enters the exhibition hall, a list of currently ongoing exhibitions is displayed and the user can view the exhibition by clicking on the exhibition he or she wants to see.

- Users exhibiting works can introduce works and write impressions. Users viewing the work can write support messages or guest books, and can also leave questions about the work. In addition to using the keyboard, the user can write by hand. Users

can also place flowers or gifts. If there is a student in charge in the workspace, the user can talk through voice or chat. Users can take a photo for authentication in the exhibition hall. In addition, events are held in the exhibition hall. Users can find hidden items in the descriptions of the work and the presentation videos. Those who find them all receive a prize. Items are randomly placed for each user and are placed differently even for multiple visits.

● When a user leaves the exhibition hall, they can vote for their favorite work. In addition, it notifies the user through the window of the work that the user had the longest viewing time.

3.3. User Characteristics

3.3.1. System Administrator

The system administrators defined in this document are those who are well aware of the ultimate goals and directions of service provision and can meet them. System administrators who have majored in computer science are familiar with software engineering and can apply it. It is assumed that system administrators should have a high understanding of the VRChat environment. System administrators accurately identify each characteristic of the hub, classrooms, library, and exhibition hall, which are spaces to be serviced, and complete the space by creating necessary models and functions. In addition, it is possible that system administrators build a database that can be used in VR Chat.

3.3.2. User

The users defined in this document are college students and professors. They can read and understand Korean and English. College students can study and participate in various internal and external activities in the Campus hub which includes hub, classrooms, library, and exhibition hall. Professors can give lectures at designated times and communicate with students through office hours in the college hub, especially lecture rooms. Users can use the service with desktop or laptop.

3.4. Constraints

The Campus Hub will be designed and implemented with strict compliance and consideration pertaining to the list of constraints as listed below.

- Make use of open-source software, technologies, and APIs that have already been proven reliable, stable, and reputable in the market.
- VRChat load time should not exceed 10 seconds.
- Avoid the use of paid, subscription-based, or license-based software or technologies.
- System must be designed and implemented in a way that that overall system is easy to upgrade, update, or improve even for non-pioneer developers.
- System must be designed and implemented in a way that is user-friendly, convenient, and has good adaptability from users' perspective.
- System cost, maintenance cost, and potential future advances cost must be taken into consideration.
- Add comments to code and write a code manual for non-pioneer developers.
- Develop system by VRChat environment using Unity 2019.4.30f1 or better.
- Consider source code optimization to prevent system resources wastage.
- The quality of the overall hub must be adhered to such as ensuring that each place within the hub serves its rightful purpose.
- The benefits of the system must not only be monetary benefits from the developers or clients' perspectives but more importantly, considering what users can gain from using the developed system.
- Potential risks and security issues from both system and users' perspective should always be taken into consideration throughout the entire system development process.
- Ensure the compatibility of the system with OSs such as Windows, mac OS, android, and iOS.

3.5. Assumptions and Dependencies

The design and implementation of the Campus Hub's system is based on the assumption that it will be entirely developed using VRChat environment with Unity 2019.4.30f1 or better and other relevant open-source software and technologies only. Thus, despite full consideration towards OS's compatibilities, the system may still not be applied to or be

compatible with other OSs or versions. Nevertheless, foreseeably, the spectrum of dependencies will gradually increase, when updating, upgrading, and improvements are done to the system.
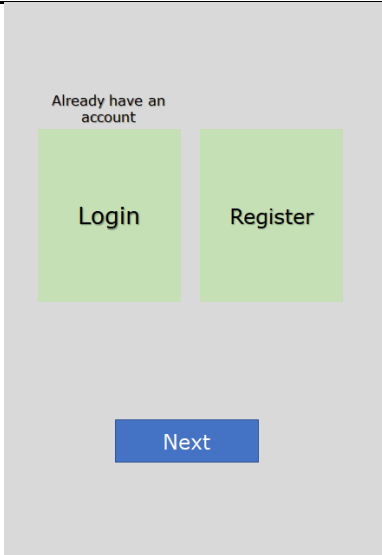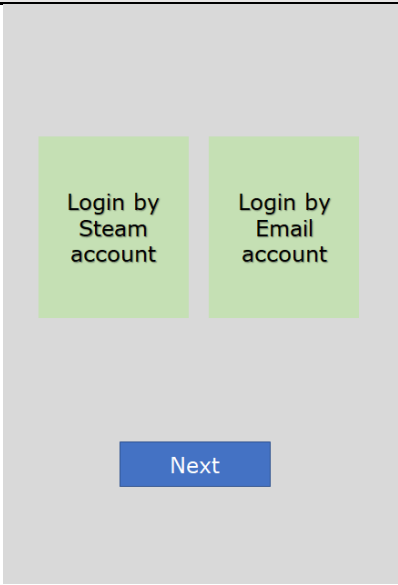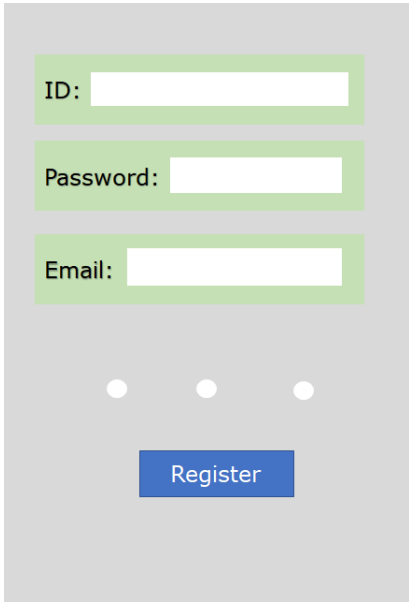
4. Specific Requirements
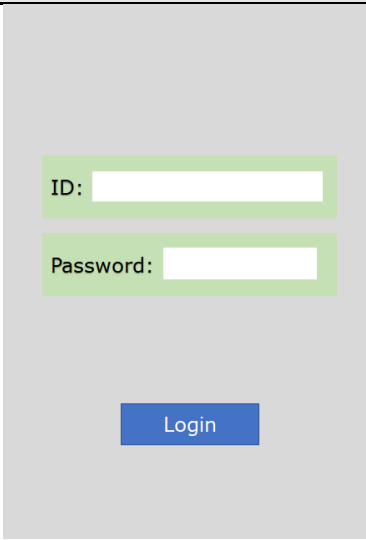
4.1. External Interface Requirements

4.1.1. User Interfaces

The user interface for the software shall be compatible to any desktop type by which user can access to the system. The UI shall be implemented using VRChat tool.
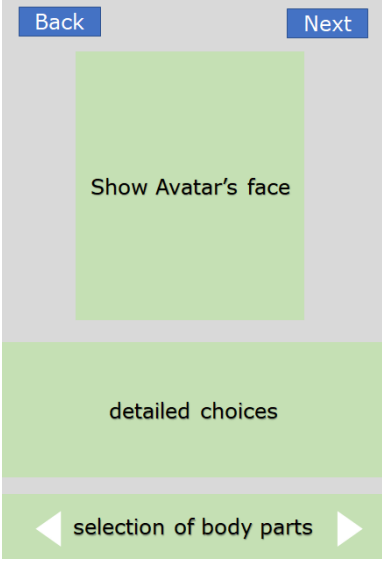
[Table 4] User interface of register & login
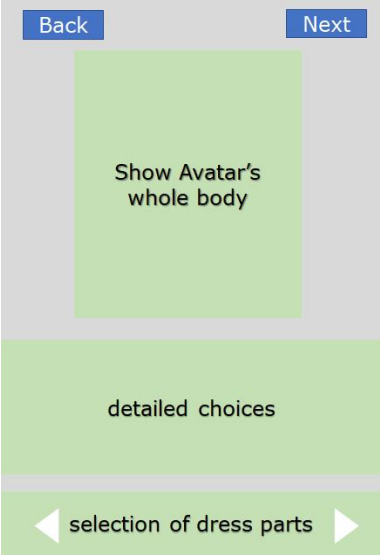
Name	Register & Login
Purpose/Description	In order to use the service of the system, users have to register to the system, followed by login process. During registration, they are asked to fill out the registration form.
Unit	A click
Instruction type	Instruction mapped to the button
Data type	Query
Format and configuration of screen	 1. Depending on whether the user has logged in at least once, either login or register

Name	Register & Login
	2. When a user uses the app for the first time, the user chooses how to register an account 3. Several empty slots for filling out necessary information of users in a vertical direction

In the Register & Login panel:

Login by Steam account   Login by Email account

Next

2. When a user uses the app for the first time, the user chooses how to register an account

ID:

Password:

Email:

Register

3. Several empty slots for filling out necessary information of users in a vertical direction

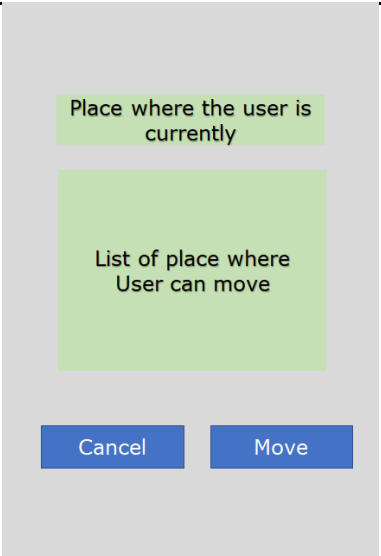| Name	Register & Login
	    ID: [ ] Password: [ ] [Login] 4. After successful registration process, the users are directed to the first page for log-in
Exit message	"Successfully registered"

[Table 5] User interface of avatar setting
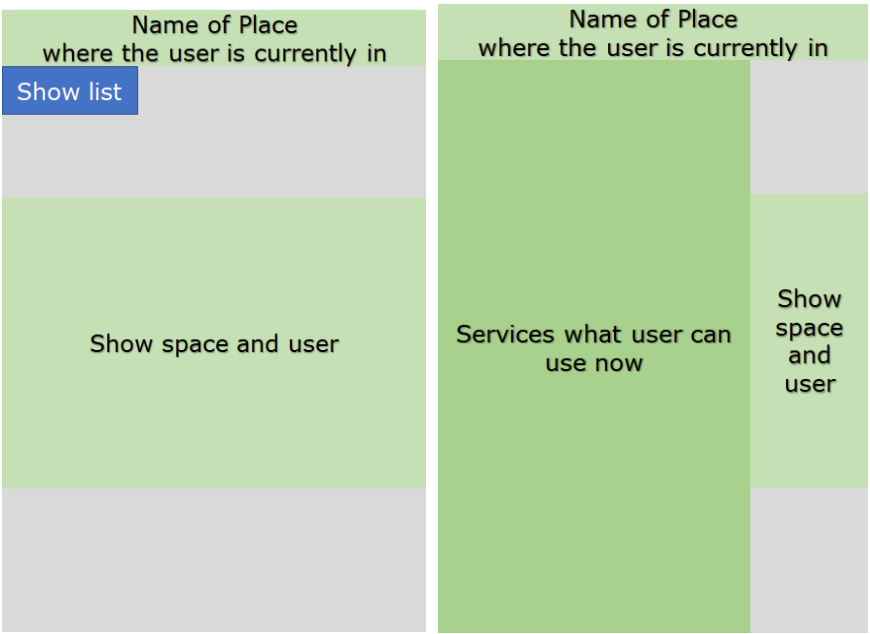
Name	Avatar setting
Purpose/Description	After registration, users decorate their avatars
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	[Back] [Next] Show Avatar's face detailed choices ◀ selection of body parts ▶ 1. The user selects a specific body part, such as eyes, nose, and mouth, and chooses the one he likes from a variety of options. Depending on the selection, you can immediately check the appearance of the avatar.

Name	Avatar setting
	Back Next Show Avatar's whole body detailed choices ◀ selection of dress parts ▶ 2. The user selects a high-level category such as tops, bottoms, and accessories. The user can select the option of detailed clothes and check it at any time as well.
Exit message	"Avatar has been created"

[Table 6] User interface of space movement
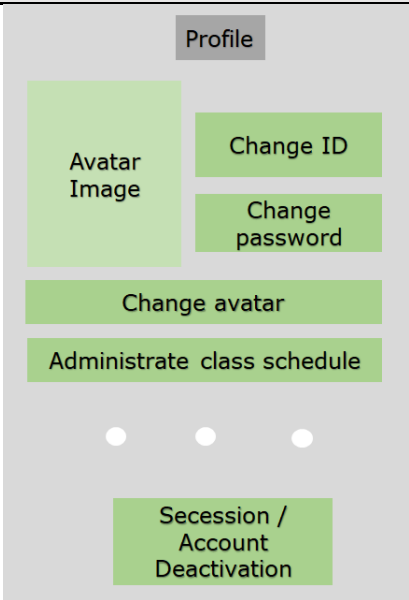
Name	Space movement
Purpose/Description	Users can freely move between HUB, Classroom, Library, and Exhibition space.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	A list of spaces except for the current space is displayed, and the user can move by clicking on the list bar where the space is written. Place where the user is currently List of place where User can move Cancel Move
Exit message	"User moved from (departure space) to (arrival space)"

[Table 7] User interface of item details

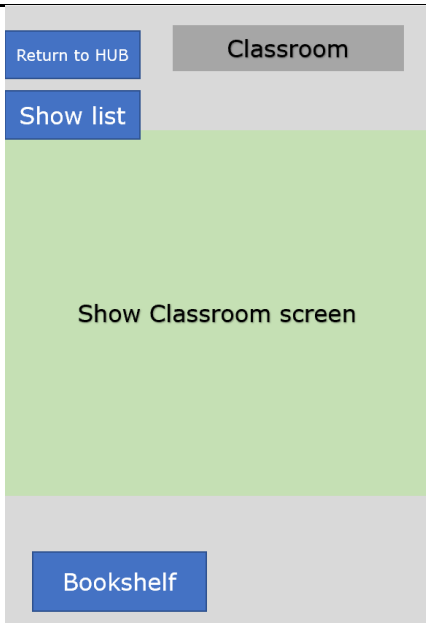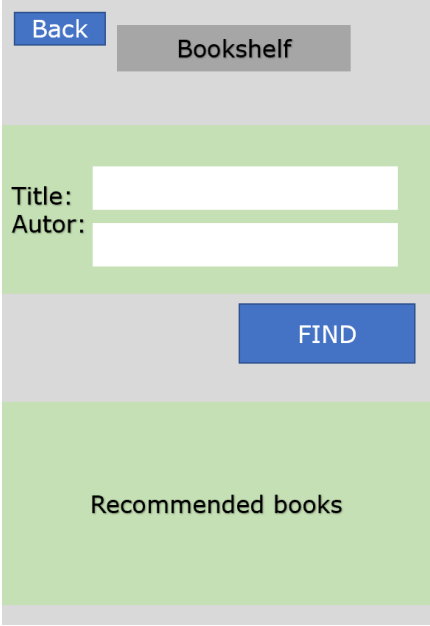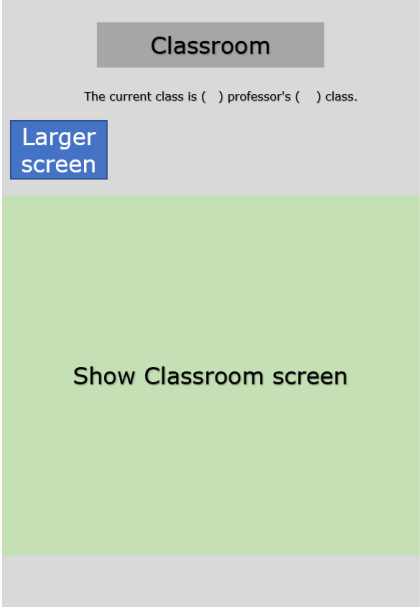| Name	Item details
Purpose/Description	After entering the new space, users can use various functions.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	Users can check the services (functions) available in the current space by clicking the upper left bar.

[Table 8] User interface of profile

Name	Profile
Purpose/Description	After log-in, users can enter the 'Profile' page by clicking a button 'profile' in order to edit their information and administrate the class schedule.
Unit	Page
Instruction type	Instruction mapping according to the value of a button code

Name	Profile
Format and configuration of screen	
Exit message	"Profile is updated"
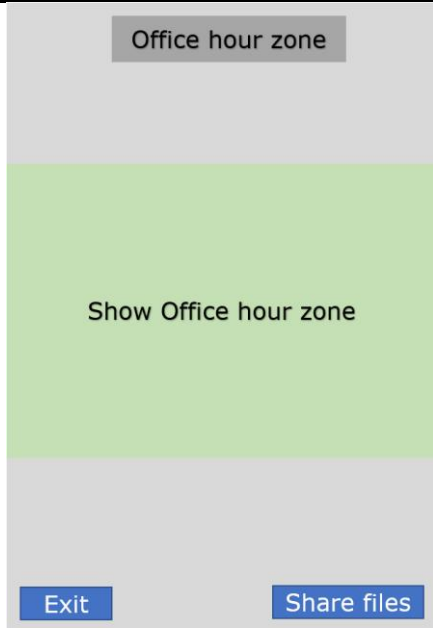
[Table 9] User interface in Classroom

Name	Classroom
Purpose/Description	After entering the classroom, user can use the bookshelf.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	 1-1. This screen is displayed if there is no class currently in progress. If the user click 'Bookshelf' button, it moves to 1-2. If the user click 'Return to HUB'

	button, user return to HUB space. **Back** **Bookshelf** Title: Autor: FIND Recommended books 1-2. Users can enter and check the name of the textbook for the subject, and they can receive book recommendations related to the textbook based on the library e-book material. **Classroom** The current class is ( ) professor's ( ) class. **Larger screen** Show Classroom screen 2. This screen is displayed if there is a class currently in progress. Students users who are seated at a distance can watch a screen projected through a camera placed in front of the classroom by clicking 'Larger screen' button.
Exit message	"User is returning to HUB"

[Table 10] User interface in Office Hour

Name	Office Hour
Purpose/Description	After entering the classroom, users can consult with professors in the office hour zone.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	1. When user click 'show list' and 'move to office hour zone', user moves to office hour zone. 2. When user enter office hour zone, user can select professor to counsult.

3-1. After selecting professor, the user can enter, and if there is a reservation. Users can share files such as resumes and documents by clicking 'share files' button and select files. If the user click 'Exit' button, user came back to the classroom space.

3-2. if there is a reservation, "in conversation" will be displayed on the door and the user will not be able to enter.

[Table 11] User interface in Library
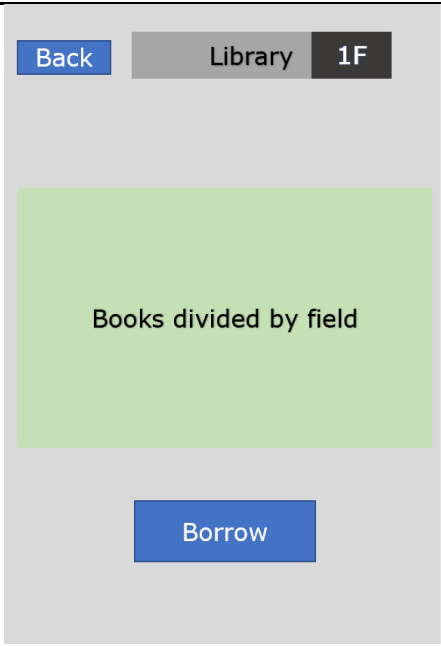
Name	Library
Purpose/Description	After entering the Library, users can select floor.

Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	 1. After entering the Library, users can select floor. 2-1. After entering 1st floor, user can borrow book or visit notice board.

	Back Library **2F** Seats Select 2-2. After entering the Library 2nd floor, users can select seat and study. Back Library **3F** List of study rooms Enter 2-3. After entering the Library 3rd floor, users can use study room.
Exit message	"User is returning to HUB"

[Table 12] User interface in Library borrowing system

Name	**Borrowing system in library**
Purpose/Description	After entering the Library 1st floor, users can borrow book.
Unit	A click

Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	 The user can check the books separated by field and can borrow by clicking the borrow button.
Exit message	"(Book title) is well lent"

[Table 13] User interface in Library 2ND floor

Name	2nd floor in library
Purpose/Description	After entering the Library 2nd floor, users can select seat and study.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
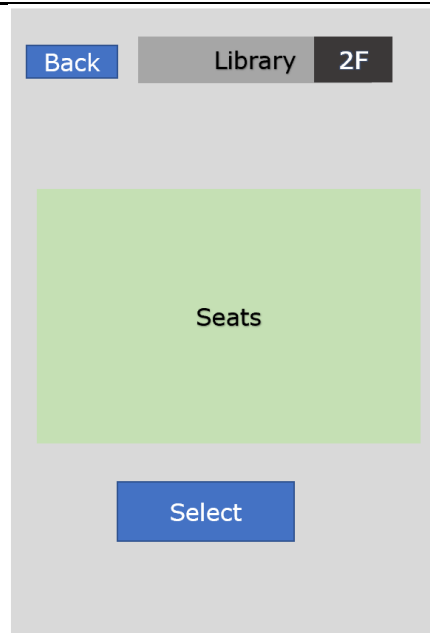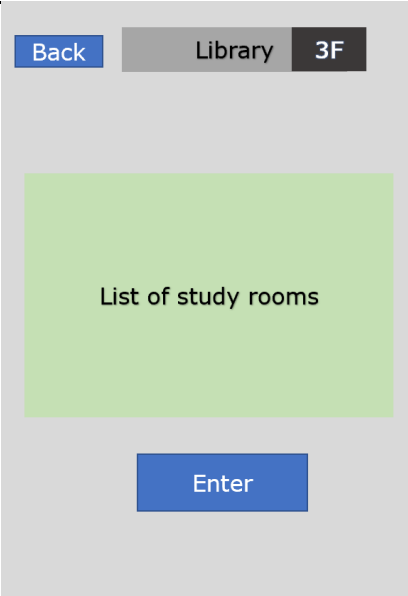
Format and configuration of screen	 **Back** Library **2F** Seats **Select** 1. After entering 2nd floor, user can check empty seats and select one. **Back** Library **2F** ID: _____ **Enter** 2. After selecting seat, user enter their ID and seat registration is done.
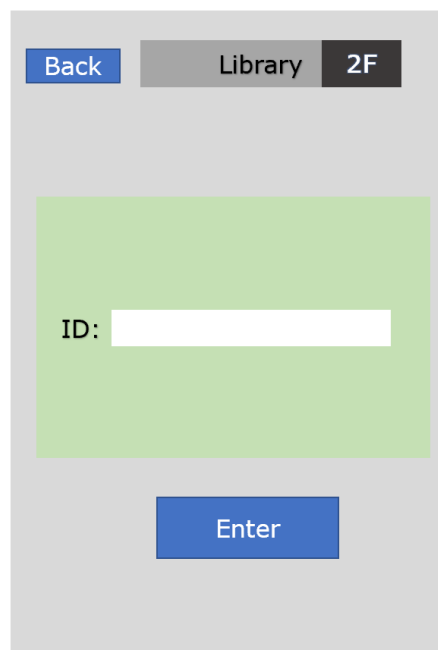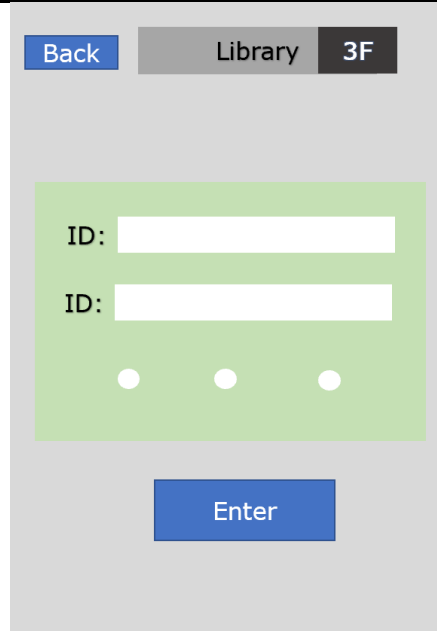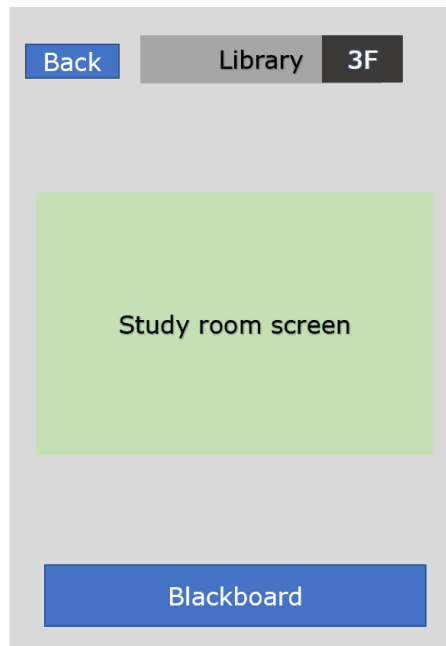
| Back | Library | 2F |

Library screen

Timer

3. After seat registration is done, timer function automatically measures study time.

| Exit message | "The user's total study time is (hours), and the rank is (number)th" |
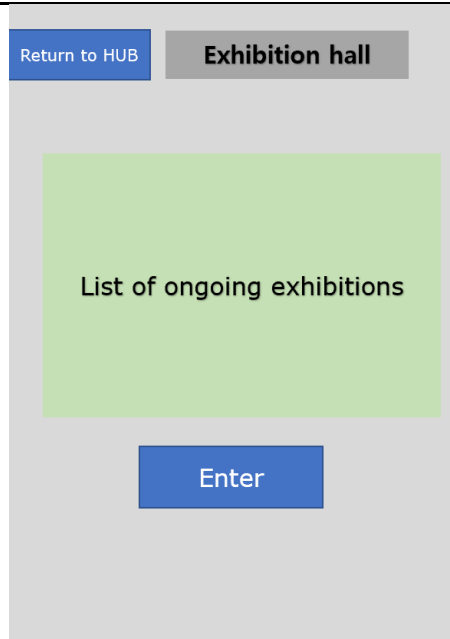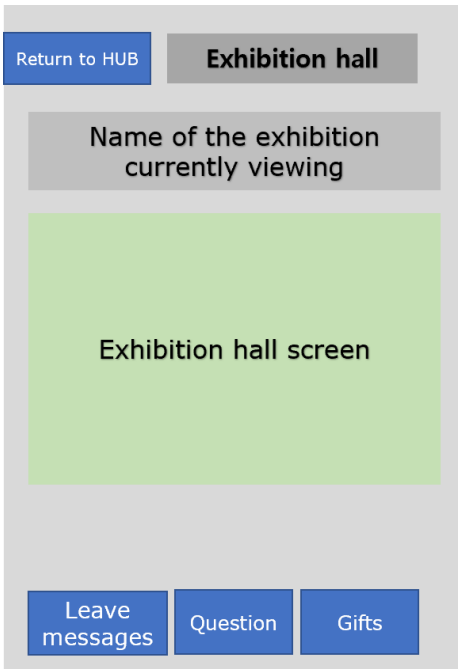
[Table 14] User interface in Library Study room
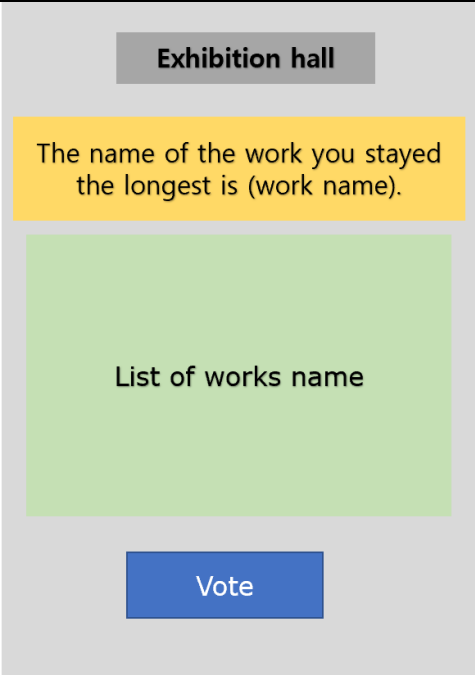
Name	Study room in library
Purpose/Description	After entering the Library 3rd floor, users can use study room.
Unit	A click
Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen

Back   Library   3F

List of study rooms

Enter

1. After entering 3rd floor, the user can check the list of empty study rooms and can enter the room he likes by pressing the enter button. |

2. Users can use the study room after entering the IDs of all the people who will use the study room.

3. After entering study room, users can use the blackboard that everyone in the study room can view, and they can discuss in the form of chat or voice.

[Table 15] User interface in Exhibition hall

Name	Exhibition hall
Purpose/Description	After entering the exhibition hall, user can enjoy the exhibition.
Unit	A click

Instruction type	Instruction mapping according to the value of a button code
Format and configuration of screen	**Return to HUB** **Exhibition hall** List of ongoing exhibitions Enter 1. When the user enters the exhibition hall, a list of currently ongoing exhibitions is displayed and the user can view the exhibition by clicking on the exhibition he or she wants to see. **Return to HUB** **Exhibition hall** Name of the exhibition currently viewing Exhibition hall screen Leave messages Question Gifts 2. Users viewing the work can write support messages or guest books by clicking 'leave messages' button, and can also leave questions about the work by clicking question button'. Users can also place flowers or gifts by clicking 'gifts' button. when user clicks 'return to HUB' button screen changes like 3.

	Exhibition hall The name of the work you stayed the longest is (work name). List of works name Vote 3. When a user leaves the exhibition hall, they can vote for their favorite work. In addition, it notifies the user through the window of the work that the user had the longest viewing time.
Exit message	"User is returning to HUB"

4.1.2. Hardware Interfaces

This section defines the logical characteristics of each interface between the software product and the hardware components of the system. Since the application must run over the internet, all the hardware shall require to connect internet will be hardware interface for the system.

[Table 16] Hardware interface of applicable device for the system

Name	Applicable device for the system
Description	PC at least Intel i5-4590 CPU or AMD FX83050 with 4GB RAM and NVIDIA GeForce® GTX 970 or AMD Radeon™ R9 290 or Intel UHD Graphics 610 graphic card enables users to take advantage of the service

4.1.3. Software Interfaces

We have chosen Windows 10 as OS for its best support and user-friendliness using

our service.

4.1.4. Communication Interfaces

This section describes any communication interfaces to other systems or devices such as local area networks, remote serial devices, and etc.

[Table 17] Communication interface of user and server

Name	User and Server
Description	Each client requests the HTTP connection to the server, requesting stored data in the server. Examples of server providing data is following. ● fundamental user data ● data related to classroom such as timetable of each user ● data related to library services such as booking/returning, reading room/study room reservation ● data related to exhibition hall such as voting
Input source	Client
Output destination	Server
Unit	packet
Throughput	At least 10Mbps
Relationship with other input/outputs	Related to all inputs/outputs from server
Data type	Query
Instruction type	Query statement

[Table 18] Communication interface of server and VRChat

Name	Server and VRChat
Description	Server requests the HTTP connection to the VRChat to receive video. Then VRChat provides corresponding stored Youtube video to server.
Input source	Server
Output destination	VRChat
Throughput	At least 10Kbps ~ 5Mbps
Relationship with other input/outputs	Related to all inputs/outputs(Youtube video) from VRChat

Name	Server and VRChat
Data type	Query
Instruction type	Query statement
Exit message	N/A

4.2. Functional Requirements

4.2.1. Use Case

[Table 19] Use case of construction

Use case name	Construction
Actor	Administrator
Description	Construct each space.
Normal Course	Administrators construct the hub, library, classroom and exhibition hall.
Precondition	VRChat provides facilities for building world and room.
Post Condition	N/A
Assumptions	N/A

[Table 20] Use case of entering the Campus Hub

Use case name	Entering the Campus Hub
Actor	Unregistered user
Description	It is provided for users who are not invited to the campus hub.
Normal Course	1. All the users have to register VRChat first. 2. User ID should contain his/her student ID. 3. Search the ID 'skku_metaverse' and add to friend. 4. If student ID is valid, Administer accept requestion and invite user to The Campus Hub.
Precondition	The user is not registered to the system yet The user enters correct information. The same email address should not be overlapped with that of other users The users should use their own student ID to be not overlapped with that of other users.
Post Condition	N/A

Use case name	Entering the Campus Hub
Assumptions	All user use their own student ID. The student ID of user is not exposed to stranger.

[Table 21] Use case of managing profile

Use case name	Managing Profile
Actor	Registered user
Description	It is provided for users to manage class timetable, major, grade and academic status.
Normal Course	1. Activate menu tab by press ESC button in keyboard. 2. Click "profile" menu 3. Register or update profile. 4. If updating profile is done, click "save" button and close the menu by click "exit" button.
Precondition	N/A
Post Condition	N/A
Assumptions	VRChat support the menu tab.

[Table 22] Use case of space movement

Use case name	Space movement
Actor	Registered user
Description	Space movement is a process when a user in the campus hub tries to get into other space and get out from current space.
Normal Course	1. A user who is in a space in the campus hub wants to move other space. 2. Activate menu tab by press ESC button in keyboard. 3. Click "move" menu and select where to go 4. User moves to the space by screen transition by changing object coordinates. <Classroom> 　　1. The user only can get into the class which is registered in user's class timetable.
Precondition	The user update class timetable.
Post Condition	N/A
Assumptions	N/A

[Table 23] Use case of upload file

Use case name	Upload File
Actor	Registered user
Description	The user uploads own file as lecture note, photo, or transcript etc.
Normal Course	1. The user upload copy URL of image file which is to be uploaded. 2. The user clicks the upload button on screen board in classroom, notice board in hub or library, exhibition hall, office hour zone and counseling room. 3. The user pastes the URL and click save button. 4. The user click upload button and click delete button to delete the file.
Precondition	The user uploads the file as image on website. URL is valid.
Post Condition	URL is valid.
Assumptions	URL is valid.

[Table 24] Use case of chatting

Use case name	Chatting
Actor	Registered user
Description	It is provided for the users who wants to chat with others.
Normal Course	1. A user clicks double B user and click "chat" button. 2. B user receives a chatting request from A. 3. B user accept or decline the chat by click "accept privately", "accept public" or "decline" buttons. 4. The chatting board appears to both screen. 5. The users chat by write message on the chatting board or voice. 6. A and B users quit the chat by click "exit" button on the chatting board.
Precondition	The microphone and speaker are set on both users.
Post Condition	N/A
Assumptions	N/A

[Table 25] Use case of Hub

Use case name	Hub
Actor	Registered user
Description	Users can play games such as chess and billiards or watch a movie in the entertainment space of HUB. Users can also rest on a beanbag.

Use case name	Hub
Normal Course	1. The user is located at the hub when enter the campus hub. 2. The user can enter the hub from other spaces.
Precondition	N/A
Post Condition	N/A
Assumptions	N/A

[Table 26] Use case of game

Use case name	Game
Actor	Registered user
Description	Users can play games such as chess and billiards.
Normal Course	1. The user enters the hub and goes entertainment area. 2. The user clicks chess board or billiards board. 3. Each game is started when two users are participated. 4. The user quit the game by click "quit" button.
Precondition	The user goes to entertainment area to click each game board.
Post Condition	N/A
Assumptions	N/A

[Table 27] Use case of movie

Use case name	Movie
Actor	Registered user
Description	Users can rest on a bag.
Normal Course	1. The user enters the hub and goes entertainment area. 2. The user clicks the movie screen and write URL of a movie in website as Youtube. 3. The movie is started on the screen. 4. The user can stop the movie by click the screen. 5. The user quits the movie by click the screen and delete URL.
Precondition	The network is connected. The URL is valid.
Post Condition	N/A
Assumptions	Server of the URL is not broken down.

[Table 28] Use case of beanbag

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Use case name	Beanbag
Actor	Registered user
Description	Users can rest on the beanbag.
Normal Course	1. The user enters the hub and goes entertainment area. 2. The user clicks the beanbag and press down button on the keyboard to take a seat. 3. The user get up by pressing up button on the keyboard.
Precondition	N/A
Post Condition	N/A
Assumptions	N/A

[Table 29] Use case of attendance

Use case name	Attendance
Actor	Registered user
Description	It is provided to check attendance of a user who enters the library or classroom

Normal Course	<Library>
	    1. The user select library among spaces in 'move" menu
	    2. The system checks the user's ID.
	    3. Add attendance data in library database.
	    4. The user moves other spaces.
	    5. The system checks the user's ID.
	    6. The attendance data is modified
	<Classroom>
	    1. The user gets into the class which is registered in user's class timetable.
	    2. The system checks the user's ID.
	    3. Add attendance data in classroom database.
	    4. The user moves other spaces.
	    5. The system checks the user's ID.
	    6. The attendance data is modified.

Precondition	The system connected to database by HTTP.
Post Condition	N/A
Assumptions	N/A

[Table 30] Use case of class

Use case name	Class
Actor	Registered user
Description	Professor and students who are registered in the class participate the class in the classroom.
Normal Course	1. The users cannot go out until the class is finished if class is started. <Professor> 1. The user uploads a lecture note as image file on a screen board in the classroom 2. Each image files of the lecture note is passed to next page or previous page when the user click the right mouse button to go to the next page, and click the left button to go to the previous page. 3. The user control start and end of the class by click "start" and "end" button on the side of screen board. <Student> 1. The user automatically enters the classroom when the time is up. 2. The user sits down a chair and control the camera on the desk. 3. The user can ask a question to professor by click a "Question" button on the desk.
Precondition	The user connected speaker and microphone to VRChat. The user registered the class in user's class timetable.
Post Condition	The system must save the attendance information.
Assumptions	N/A

[Table 31] Use case of desk camera

Use case name	Control Desk Camera
Actor	Registered user
Description	The user who sits on a chair in the class control a camera on the desk to watch screen.
Normal Course	1. The user sits down a chair and control the camera on the desk. 2. The Camera ignores the students in the front seats and shows front of class with professor and blackboard.
Precondition	A camera is set on a desk. A camera lens is set in front of any other desk.
Post Condition	N/A
Assumptions	Location of a camera lens does not change.

[Table 32] Use case of question button

Use case name	Question Button
Actor	Registered user
Description	The user who sits on a chair in the class ask a question to professor.
Normal Course	1. The user can ask a question to professor by click a "Question" button on the desk. 2. When the user click a question button, the "question" ring is occurred.
Precondition	The "question" ring is set in the classroom.
Post Condition	N/A
Assumptions	N/A

[Table 33] Use case of automatic class entering

Use case name	Automatic class entering
Actor	System
Description	Move users to class automatically when the time is up.
Normal Course	The system changes the object coordinate of the user when the time is up.
Precondition	N/A
Post Condition	N/A
Assumptions	N/A

[Table 34] Use case of reservation

Use case name	Reservation
Actor	Registered user
Description	A user or users make a reservation office hour zone.
Normal Course	1. The user click "register" button beside of the office hour zone door in the classroom. 2. The user selects the time when to do. 3. The user writes all of student ID of participations and click "save" button.
Precondition	N/A
Post Condition	The reserved time is grayed out on the next reservation screen.
Assumptions	N/A

[Table 35] Use case of office hour

Use case name	Office hour

Use case name	Office hour
Actor	Registered user
Description	A user or users can communicate with professor privately for asking some question about class.
Normal Course	1. Reserved user or user who access when there is no reserved user click office hour zone door in the classroom and enter the office hour zone. 2. The professor user can enter the office hour zone any time. 3. "In conversation" status on the door change color from black to red. 4. Students upload their data by upload button on the table. 5. Professor and students communicate by chatting. 6. Users get out from the office hour zone to classroom by click a door. 7. "In conversation" status on the door change color from red to black.
Precondition	N/A
Post Condition	The students delete their data before exit.
Assumptions	N/A

[Table 36] Use case of counseling

Use case name	Counseling
Actor	Registered user
Description	A user or users consult each other in the counseling room.
Normal Course	1. The user clicks the counseling room door in the classroom to enter counseling room. 2. The counseling room is locked by click "lock" button on the door in the room 3. The users upload their data by upload button on the table. 4. The users delete their data before exit. 5. The users get out from the room to classroom by click the door. 6. Lock is released.
Precondition	The counseling room is not locked.
Post Condition	The users delete their data before exit.
Assumptions	N/A

[Table 37] Use case of bookshelf

Use case name	Bookshelf
Actor	Registered user
Description	It is provided to inform the textbook and related books of the class.

Use case name	Bookshelf
Normal Course	1. The user clicks the bookshelf in the classroom. 2. If there is no book, user click "add" button and write textbook name to search and choose appropriate one and click save button. 3. The textbook is shown on the bookshelf. 4. The related books are shown on the side of textbook
Precondition	The book list is uploaded. The textbook is existed in the book list. The related books are recommended by machine learning.
Post Condition	N/A
Assumptions	N/A

[Table 38] Use case of elevator

Use case name	Elevator
Actor	Registered user
Description	The user can visit each floor of the library by using elevator.
Normal Course	1. Elevator exists at center of each floor. 2. 1st floor has only "up" button, 3rd floor has only "down" button and 2nd floor has both. 3. If the user click "up" or "down" button, elevator move to that floor and elevator door is opened. 4. The user gets on the elevator and click a number button to move that floor. 5. The user can open or close the door by click "open" or "close" buttons. 6. If the elevator arrives at destination, the door is open and user can get out.
Precondition	The door is not controlled when the elevator is operated. The elevator does not move if the door is not closed
Post Condition	N/A
Assumptions	N/A

[Table 39] Use case of bookshelves in library

Use case name	Bookshelves in Library
Actor	Registered user
Description	The user can view, borrow and return books in the bookshelves.
Normal Course	1. The user enters 1st floor of library and click bookshelves. \<View\> 1. After click, the list of fields of books are shown and user selects a

Use case name	Bookshelves in Library
	desired field.
	2. The user checks the list of books.
	<Borrow>
	1. After click, there is a "search" button and the user can search a desired book.
	2. The user clicks the book by "search" button or searching it himself/herself by viewing and click "borrow" button.
	3. The rental information is updated on the database.
	<Return>
	1. The system push alarm by message before 14 days have passed from rental day.
	2. The user clicks the bookshelves and click "return" button.
	3. The rental history of the user from database is shown.
	4. The user clicks some books to return and clicks "return" button.
Precondition	The system should be connected with database.
Post Condition	The rental and return information must be updated in the database.
Assumptions	N/A

[Table 40] Use case of posting space

Use case name	Posting Space
Actor	Registered user
Description	User can post some posts on the posting spaces.
Normal Course	1. The user enters the library.
	2. There are posting spaces in the 1st floor.
	3. The user clicks the posting space and write URL of image file where his/her post is uploaded.
	4. The user click "save" button.
	5. All users can see the post.
Precondition	Network is connected. URL is valid.
Post Condition	N/A
Assumptions	N/A

[Table 41] Use case of reading room

Use case name	Reading Room

Use case name	Reading Room
Actor	Registered user
Description	User can measure his/her study time in the reading room. It provides ranking service of the study time of all users.
Normal Course	1. The user enter the 2nd floor of library. 2. Users can register by clicking an empty seat and press "down" button of keyboard to take a seat. 3. The entering information is updated on the database. 4. After entering, the study time of users is automatically recorded by system. 5. The user leaves out from the seat by press "up" button on the keyboard and then seat registration is automatically canceled. 6. After leaving, the study time of this time, total study time and average study time of the user are shown on the window. It is closed by click "X" button. 7. A ranking service is provided based on history in the database. 8. High 10 users are registered on the bulletin board. 9. Users can check their average study time and ranking
Precondition	The system is connected with the database. Calculate function for total and average study time is implemented. The timer function is implemented.
Post Condition	The study time information must be updated in the database.
Assumptions	N/A

[Table 42] Use case of study room

Use case name	Study Room
Actor	Registered user
Description	User can study and discuss with other users in the study room. It is reservation system.
Normal Course	1. The user enters the 3rd floor of library. 2. The user clicks an empty study room door and write IDs of all users on the screen. 3. The information is recorded in the database. 4. A user verified by student ID enter the study room. 5. In the study room, users can use screen board to share some data as image file by click the board and write URL of the file. 6. The users can discuss in the form of chat on the chatting board or voice.

Use case name	Study Room
	7. The users can get out from the study room by click door.
	8. After using the study room, the user clicks the study room door and click "finish" button shown on the window.
	9. The user information of the study room is deleted in the database.
Precondition	The system is connected with the database. URL is valid. Microphone and speaker of user is connected VRChat.
Post Condition	N/A
Assumptions	N/A

[Table 43] Use case of exhibition

| Use case name	Exhibition
Actor	Registered user
Description	Users can post their works, vote their favorite works, comment to the works. Users watch other's work.

Normal Course	1. The user enters the exhibition hall.
	 <Post>
	
	    1. The user clicks the posting space and write URL of image file where his/her post is uploaded and click "save" button.
	 <Comment>
	
	    1. The user clicks the work and write support messages, impressions or questions on the screen and click "save" button.
	
	    2. The comment is stored in the database and it is shown when a user click the work.
	 <Vote>
	
	    1. The user click "move" menu to leave out the exhibition hall.
	
	    2. The list of work from database is shown on a window and the user can vote his/her favorite work.
	    3. Votes are stored in database and it is shown when a user click a work.
	 <Event>
	    1. Users can find hidden items in the descriptions of the work and the presentation videos.
	    2. Those who find them all receive a prize.

Use case name	Exhibition
Precondition	The system is connected with the database. URL is valid.
Post Condition	N/A
Assumptions	N/A

[Table 44] Use case of event

Use case name	Event
Actor	System
Description	The hidden item in the exhibition room is located randomly.
Normal Course	When a user find the hidden item, it generated in the exhibition room with random object coordinates.
Precondition	The random function is implemented.
Post Condition	N/A
Assumptions	N/A

4.2.2. Use Case Diagram

[Figure 1] Use case diagram
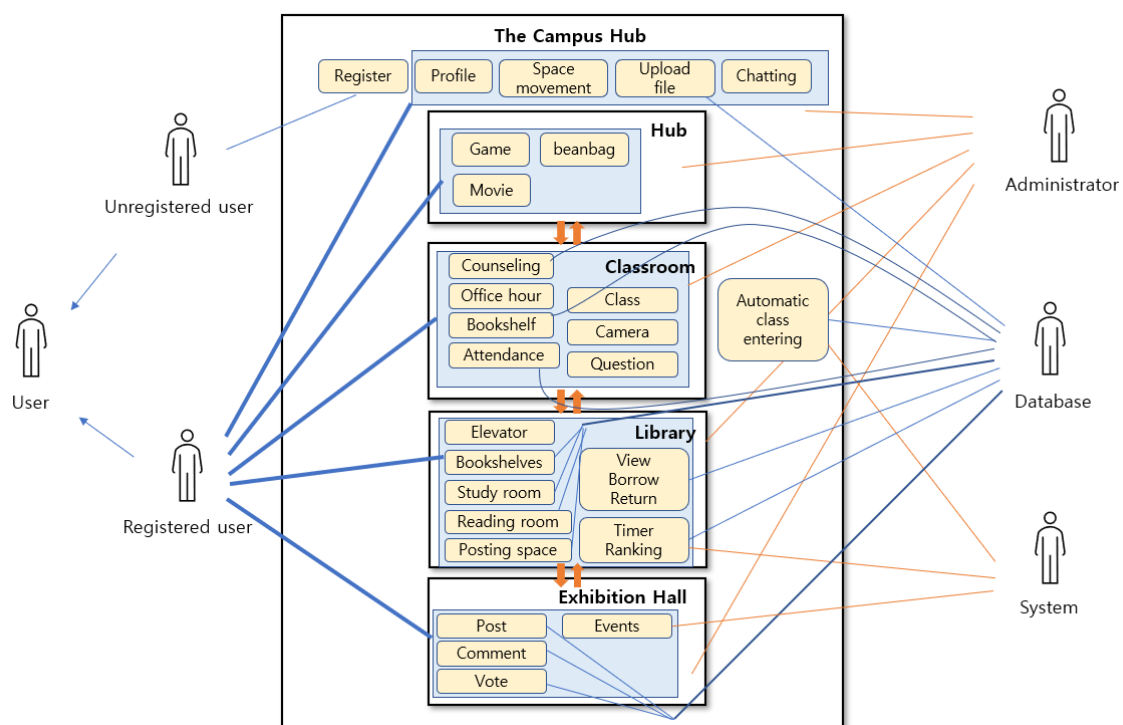
4.2.3. Data Dictionary

[Table 45] AVATAR

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
name		Not Null	Student/Professor's name	varchar(100)
hairstyle		Not Null	Avatar's hairstyle	varchar(100)
top		Not Null	Avatar's top	varchar(100)
bottom		Not Null	Avatar's bottom	varchar(100)
accessories		Not Null	Avatar's accessories	varchar(100)
shoes		Not Null	Avatar's shoes	varchar(100)
last_edited		Not Null	When avatar was last edited	Date

[Table 46] LOGOUT

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
name		Not Null	Student/Professor's name	varchar(100)
logout_time		Not Null	Time of logout	time
logout_date		Not Null	Date of logout	date

[Table 47] LOGIN

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
name		Not Null	Student/Professor's name	varchar(100)
logout_time		Not Null	Time of login	time
logout_date		Not Null	Date of login	date

[Table 48] CHAT

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
chat_id	PK	Not Null	Chat's unique id	int(20)
chat_time		Not Null	Time of chat	time
chat_date		Not Null	Date of chat	date
chat_log		Not Null	Chat log	varchar(500)

[Table 49] HUB

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)

name		Not Null	Student/Professor's name	varchar(100)
visited_time		Not Null	Time of entering hub	time
visited_date		Not Null	Date of entering hub	date
movie			Watched movie or not	BIT
game			Played game or not	BIT
rest			Rest or not	BIT

[Table 50] COUNSELING

Field	Key	Constraint	Description	Attribute
counselling_id	PK	Not Null	Counselling's unique id	int(10)
classroom_course_code	PK/FK	Not Null	Course code	varchar(10)
start_time		Not Null	Counselling start time	time
end_time		Not Null	Counselling end time	time
date		Not Null	Date of counselling	date
professor		Not Null	Counselling professor	varchar(100)
num_of_students		Not Null	Number of students	int(2)

[Table 51] CLASSROOM

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Professor's id	int(10)
course_code	PK	Not Null	Course code	varchar(10)
class_time	PK	Not Null	Class start time	time
class_date	PK	Not Null	Class start date	date
professor		Not Null	Professor's name	varchar(100)

[Table 52] USERS

Field	Key	Constraint	Description	Attribute
id	PK	Not Null	Student/Professor's id	int(10)
password		Not Null	Student/Professor's password	varchar(15)
name		Not Null	Student/Professor's name	varchar(100)
department		Not Null	Student/Professor's department	varchar(20)
email		Not Null	Student/Professor's email	varchar(20)
phone_number		Not Null	Student/Professor's phone no.	int(11)
last_edited		Not Null	Profile last edited	date
position		Not Null	Student or professor	varchar(10)
major			Student's major	varchar(20)
year_of_study			Student's year of study	int(1)
address			Student/Professor's address	varchar(100)

[Table 53] EXHIBITION

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
name		Not Null	Student/Professor's name	varchar(100)
visited_time		Not Null	Exhibition visiting time	time
visited_date		Not Null	Exhibition visiting date	date

[Table 54] ATTENDANCE

Field	Key	Constraint	Description	Attribute
classroom_course_code	PK/FK	Not Null	Course code	varchar(10)
classroom_class_time	PK/FK	Not Null	Class start time	time
classroom_class_date	PK/FK	Not Null	Class date	date
student_id	PK	Not Null	Student's id	int(10)
student_name		Not Null	Student's name	varchar(100)
status		Not Null	Absent or present	BIT
absent_reason			Why absent	varchar(50)

[Table 55] BOOKSHELF

Field	Key	Constraint	Description	Attribute
book_id	PK	Not Null	Book's unique	varchar(10)
title		Not Null	Book's name	varchar(50)
author		Not Null	Author of book	varchar(100)
publish_date			Book publish date	date

[Table 56] LIBRARY

Field	Key	Constraint	Description	Attribute
users_id	PK/FK	Not Null	Student/Professor's id	int(10)
books_book_id	PK/FK	Not Null	Borrowed book's id	varchar(10)
name		Not Null	Student/Professor's name	varchar(100)
visited_time		Not Null	Time entering library	time
visited_date		Not Null	Date entering library	date
books_borrowed			Name of borrowed book	varchar(50)

[Table 57] ONGOING

Field	Key	Constraint	Description	Attribute
exhibition_id	PK	Not Null	Exhibition's id	varchar(10)
exhibition_name		Not Null	Exhibition's name	varchar(50)
start_date		Not Null	When exhibition started	date

Field	Key	Constraint	Description	Attribute
end_date		Not Null	When will exhibition end	date
type_of_exhibiton		Not Null	What exhibition is it	varchar(20)
owner		Not Null	Name of owner of exhibition	varchar(100)

[Table 58] VOTE

Field	Key	Constraint	Description	Attribute
ongoing_exhibition_id	PK/FK	Not Null	Exhibition's id	varchar(10)
num_of_votes		Not Null	Total number of votes	int(10)

[Table 59] OFFICEHOUR

Field	Key	Constraint	Description	Attribute
reservation_id	PK	Not Null	Reservation's unique id	int(10)
classroom_course_code	PK/FK	Not Null	Course code	varchar(10)
start_time		Not Null	Start time of office hour	time
end_time		Not Null	End time of office hour	time
date		Not Null	Date of office hour	date
professor		Not Null	Professor's name	varchar(100)
num_of_students			Number of students	int(2)

[Table 60] QA1

Field	Key	Constraint	Description	Attribute
classroom_course_code	PK/FK	Not Null	Course code	varchar(10)
question_num	PK	Not Null	Question number	int(2)
question		Not Null	Question contents	varchar(500)

[Table 61] BOOKS

Field	Key	Constraint	Description	Attribute
book_id	PK	Not Null	Book's unique id	varchar(10)
title		Not Null	Book title	varchar(50)
author		Not Null	Book's author	varchar(100)
status		Not Null	Borrowed or available	BIT
publish_date			Book published date	date

[Table 62] ROOMS

Field	Key	Constraint	Description	Attribute
users_library_id	PK/FK	Not Null	Student/Professor's id	int(10)
which_room		Not Null	Reading or study room	varchar(50)
availability		Not Null	Available or not	BIT
name			Student/Professor's name	varchar(100)

date			Date of reservation	date
start_time			Start time of reservation	time
end_time			End time of reservation	time

[Table 63] VOTE

Field	Key	Constraint	Description	Attribute
ongoing_exhibition_id	PK/FK	Not Null	Exhibition's id	varchar(10)
question_num	PK	Not Null	Question number	int(2)
question		Not Null	Question contents	varchar(500)

[Figure 2] Entity Relationship Diagram
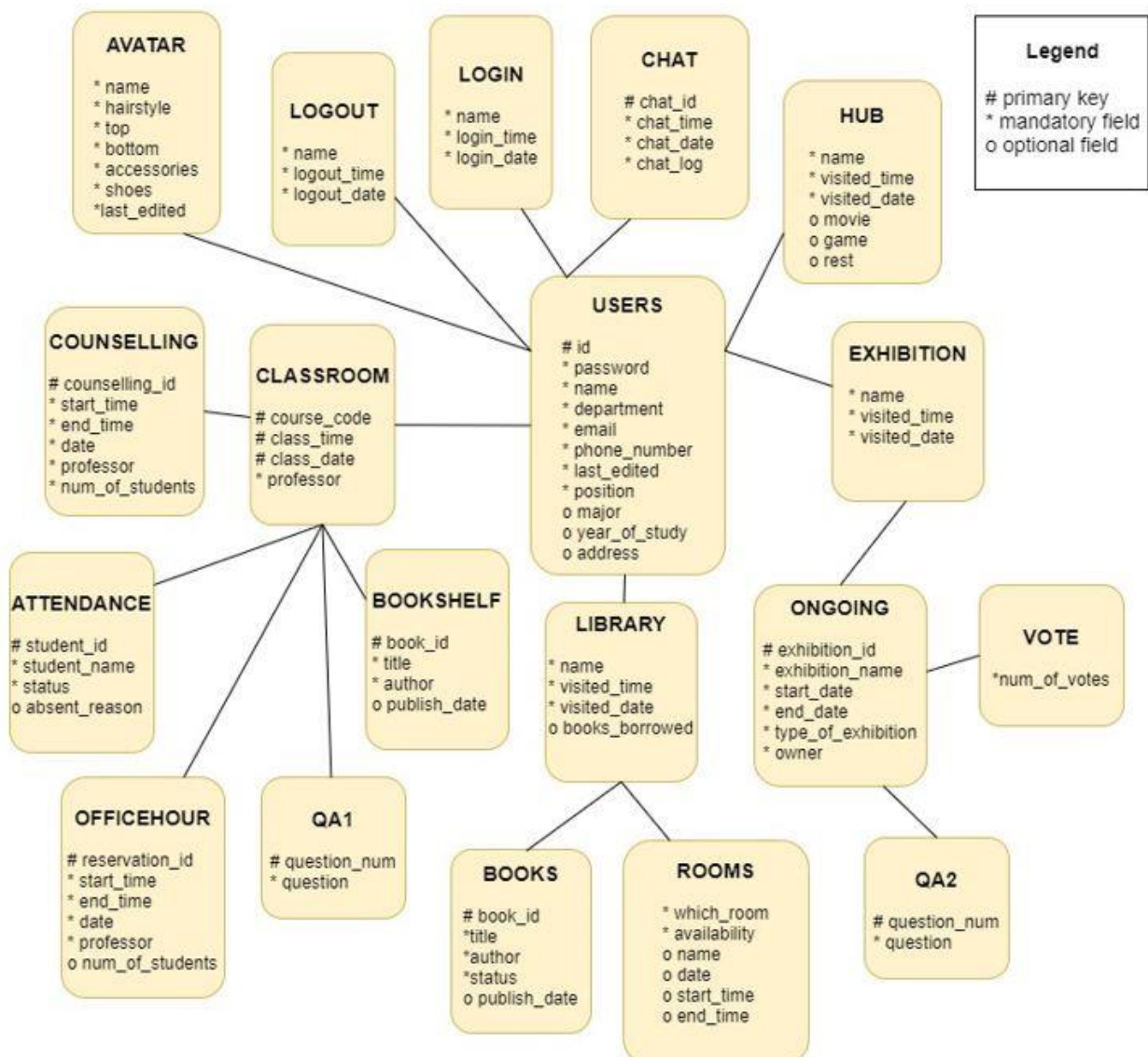
4.2.4. Data Flow Diagram

[Figure 3] Data flow diagram
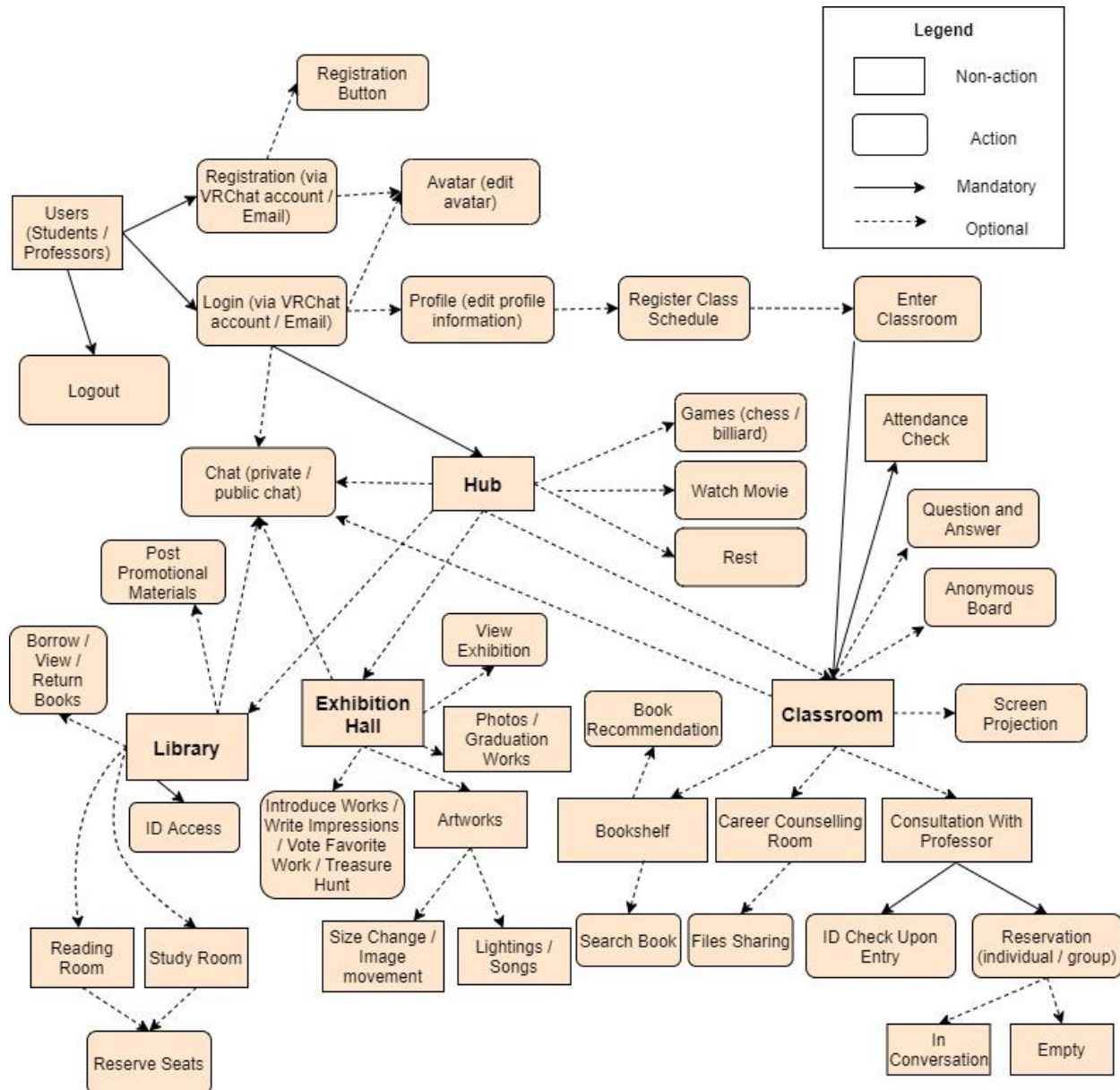
4.3. Performance Requirements

Since VRChat is selected as a metaverse platform, performance within VRChat is evaluated. The most important performance in VRChat is frame rate, which can be tested through average frame measurements in the game. In the case of VRChat, we can play it by three ways (PC, PCVR, Oculus Quest). Oculus Quest will be excluded because additional

work is required to develop it for Oculus Quest. Then, PC and PCVR remain. PCVR requires higher performance than PC, so tests can be performed based on PCVR device. PCVR is a VR device used by connecting to PC, and in the case of this VR, two high-resolution screens must be rendered, requiring higher performance than in general PC games. Based on the high-performance gaming PC, the CPU will measure the frame based on Ryzen 3600 and 16 RAMs, and the GPU of GeForce 2070 super. Based on this, it aims to produce an average frame similar to that of other general VRChat worlds when present alone in the world.

4.4. Logical Database Requirements

MySQL to maintain the database. Database will include tables for converting VRChat ID into Sungkyunkwan University's   student number, subjects that each student taking a class, schedule for each student and professor, attendance check, etc.

4.5. Nonfunctional Requirements

Software system characteristics are revealed through non-functional requirements. Therefore, this section describes several non-functional requirements of the system. Non-functional requirements are classified Product Requirements, Organization Requirements, External Requirements as follows.

4.5.1. Product Requirements

Product requirements specify or constrain the runtime behavior of the software. Our system should satisfy following requirements.

4.5.1.1. Reliability

The system should provide its purposed service at any given time. The recommendation system should provide the service while errors are minimized. Its result should be reliable as expected by user. The average number of errors made by recommendation system shall not exceed 5 percent.

4.5.1.2. Usability

This is one of most important non-functional requirements of our system. The system should be easy to use by non-technical user and should be organized in such a way that user errors are minimized. The usage of technical terms should be minimized, explain it easily if needed. Each user shall be able to use all the system functions instinctively without training time. That means, user interface should be simple, instinctive, and easy to use.

4.5.1.3. Maintainability

Users can request software changes according to the training method or exhibition schedule and characteristics. The system shall be able to accommodate these changes while maintaining a certain level of efficiency.

4.5.1.4. Security

The users should be properly authenticated before using the system. It should make sure that an unauthorized user cannot gains access as system manager and makes system unavailable. Also, an unauthorized user cannot gains access as system user to confidential information such as user's personal Information, ID, and password. Only authenticated users can modify profiles, move spaces, and chat. In addition, only users who have registered for the class can participate in the classroom. Users who are not reserved are not allowed to enter the study room. Only users who borrowed the book can access the book.

4.5.2. Organizational Requirements

These requirements are broad system requirements derived from policies and procedures in the customer's and developer's organizations.

4.5.2.1. Environmental Requirements

The system will be implemented using the VRChat platform. VRChat does not support the Web panel function. Therefore, the system will be linked with an external database using YouTube.

4.5.2.2. Operational Requirement

The system provides a virtual campus to users. Users of this system must verify their identity with their school ID. On the virtual campus, users can set up their profile or avatar,

move to a desired place, and chat with other users.

When the class that the user takes begins, the user can automatically enter the classroom and be recognized for attendance. This process is performed within 10 seconds. Classroom provides microphones, desks, and text book or references necessary for classes.

In the hub, users can play games, relax, and watch movies.

In the library in The Campus Hub, users can read, borrow, or return books. Borrowing and returns are made within 10 seconds. The library also provides a study room. Only reserved users can use this space after checking with their ID. Reservations are made within 10 seconds, and study room admission is made within 5 seconds.

Exhibition hall can appreciate exhibition works and communicate with artists by leaving messages, or leaving flowers. This process is performed within 5 seconds.

The system operates on a laptop or desktop and can operate at any time.

4.5.3. External Requirements

It covers all requirements that are derived from factors external to the system and its development process.

4.5.3.1. Regulation

Since VRChat's world is accessible to anyone playing VRChat, sources used to build a world such as music, modeling, code, shader, particles or assets in Unity Store should be carefully examined not to violate copyrights. It could lead to legal problems.

4.6. Organizing the Specific Requirements

In this section, we describe the system model describing the relationship among the system, sub-systems, components, and surrounding environments, showing more specific requirements.

4.6.1. Context Model

[Figure 4] Context model
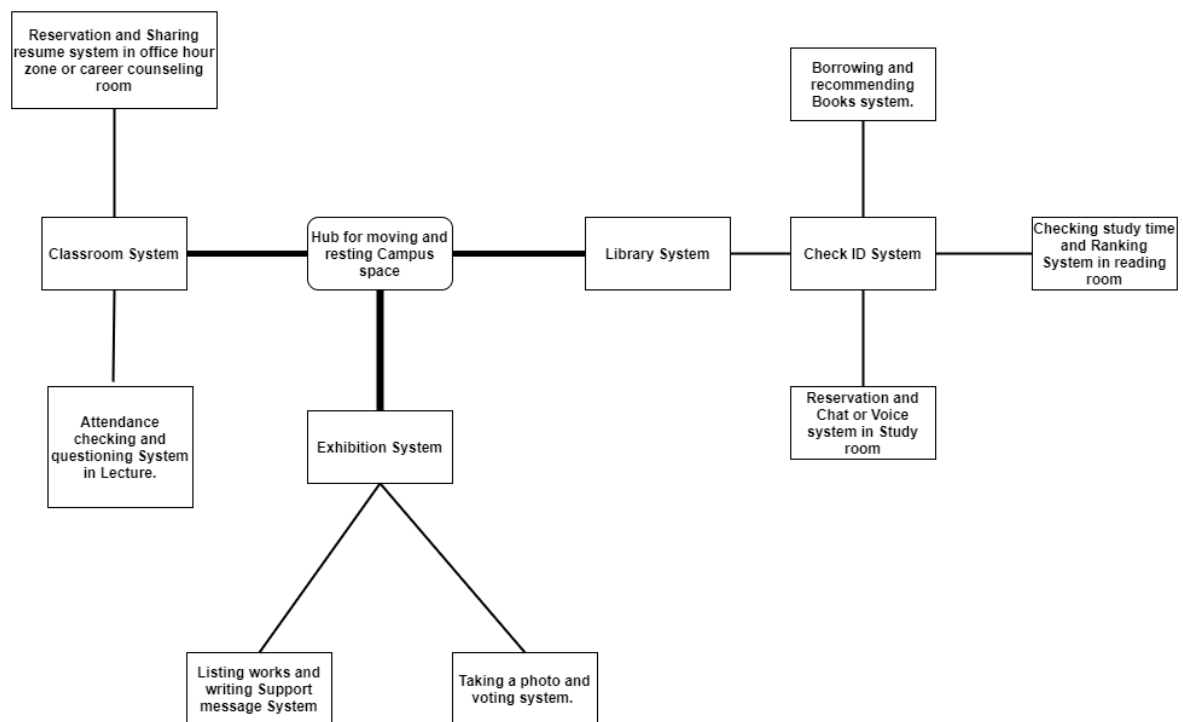
4.6.2. Process Model

[Figure 5] Overall process model
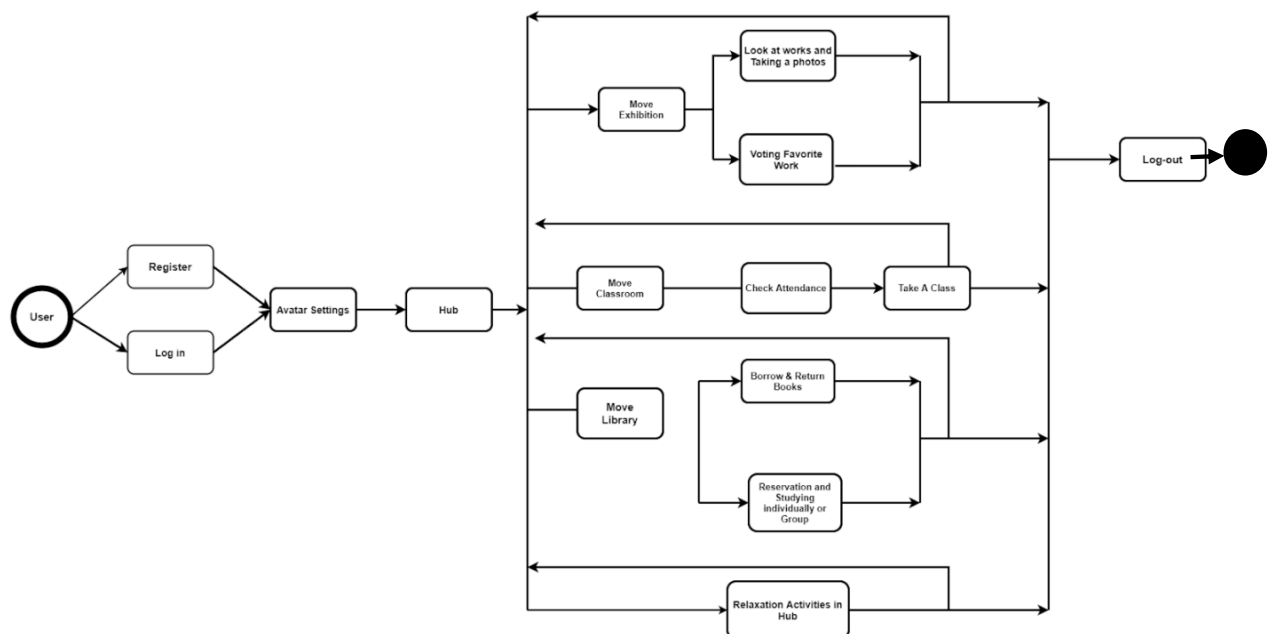
4.6.3. Interaction Model

See 4.2.2. Use Case Diagram

4.6.4. Behavior Model

4.6.4.1. Data Flow Diagram

See 4.2.4. Data Flow Diagram

4.6.4.2. Sequence Diagram

This diagram describes the sequence of functions with the hub which is our main
system.

[Figure 6] Sequence diagram
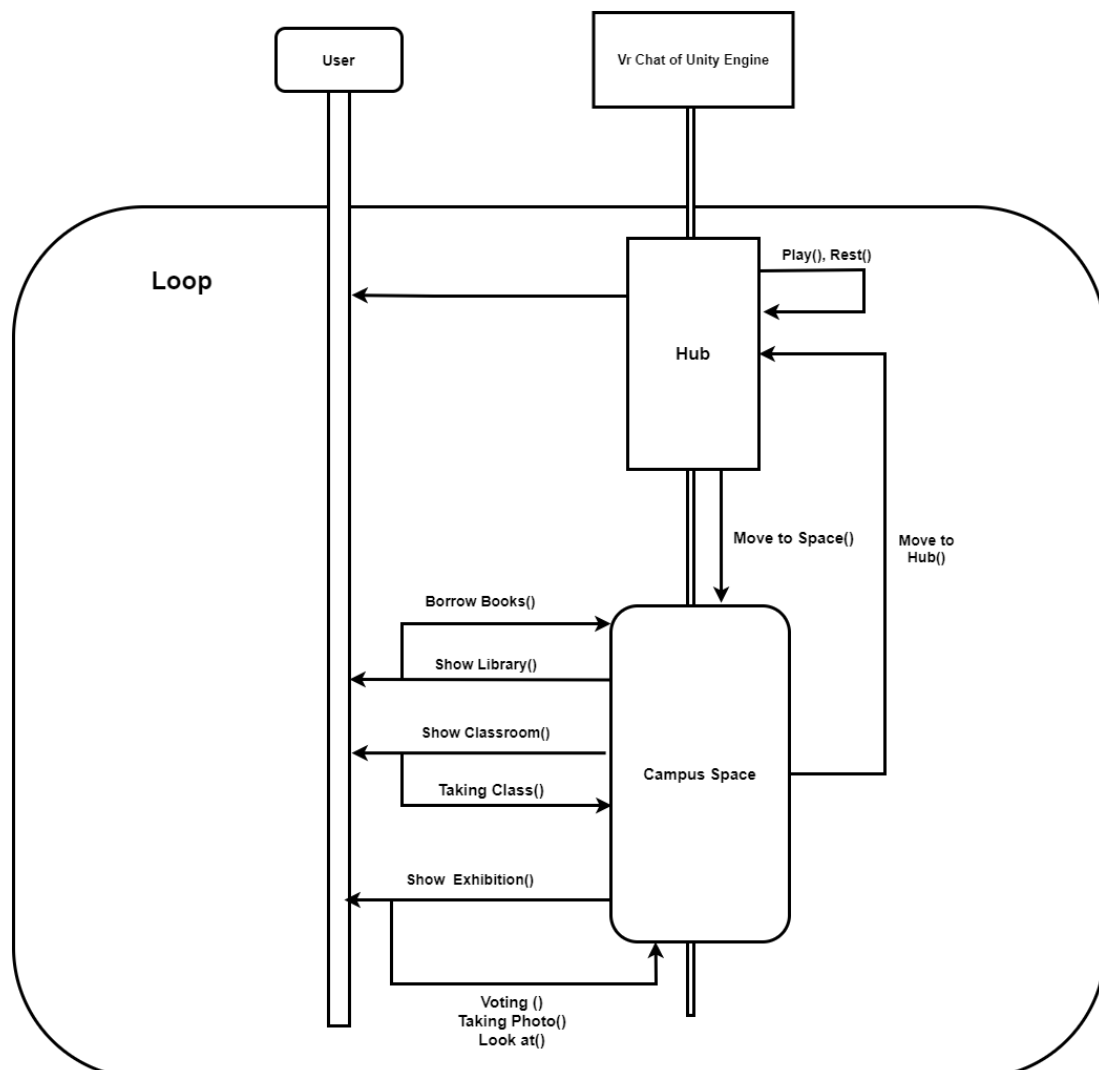
4.7. System Architecture

This part shows the expected system architecture and the distribution of functionality across system modules. Use the Model-View-Controller as a graphical model of the architecture.

[Figure 7] System architecture of the system
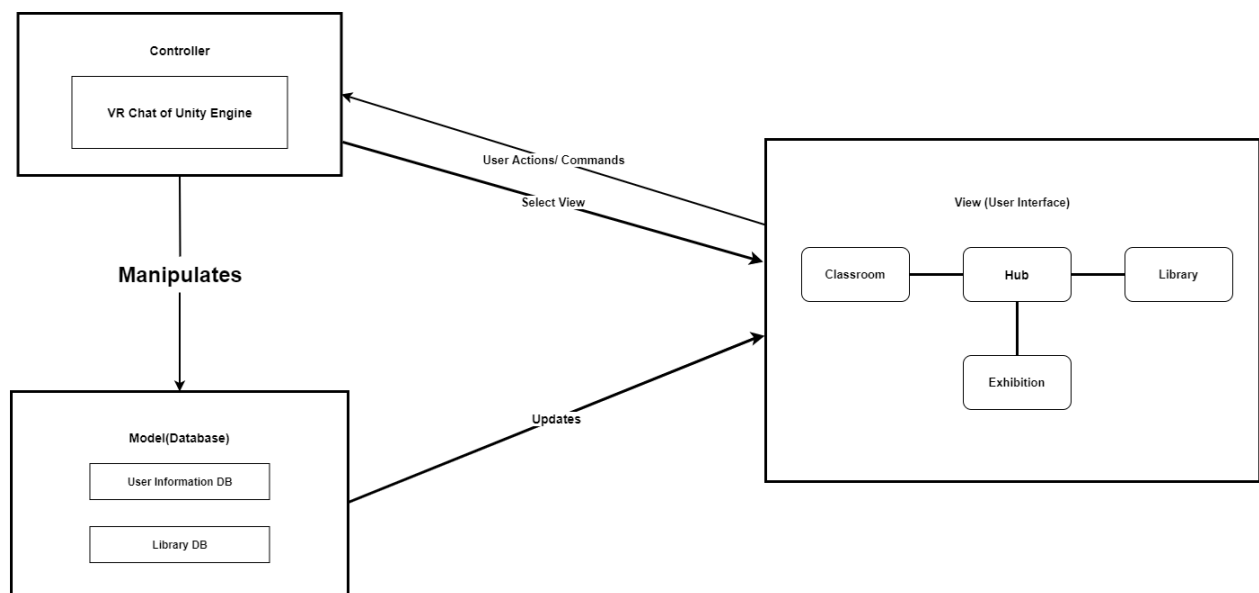
5. System Evolution

5.1.1. Limitation and Assumption

The system we made improves convenience by increasing access to various facilities within the metaverse campus space as a hub, but because of only three other spaces, classroom, library, and exhibition, there is a limitation in not being able to access all the spaces that exist on the campus.

In addition, since it focuses on the function as a hub, the systematic functions of classroom, library, and exhibition hall may not give the user the same experiential feeling as when they actually use the space. So, there is a need to expand additional space and add functional services.

5.1.2. Evolutions of Hardware and Change of User Requirements

The concept of Campus hub should be connected to implement multiple spaces that actually exist in Campus, as a stepping stone that connects the spaces that can exist in Smart Campus. However, in the case of the hub we created, we have only three spaces, so we need to implement spaces with various purposes such as laboratories, playgrounds, and auditoriums where we can stay in schools, and provide them as services.

There is also a lack of service that space has because it focuses on hub for its own purpose. User requests are advised to go through the hub to the place they want to go and do the same thing that would be done from there in a real school. Since each space is not implemented so completely, we need to change the functionality of each space to reflect the user feedback of each space. For example, in the case of a library, it is possible to develop in the direction in which borrowed information is recorded by linking with actual library data via an electronic library, and it is possible to add virtual functions that do not exist in reality. It can reflect the benefits of being able to be recorded and reflected to avoid repetitive work that may occur when adding other spaces after these changes.

6. Index

6.1. Table Index

6.2. Figure Index