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Faculty of Engineering and Applied Science

ENGR 4941U Capstone Systems Design for ECSE II

Design and Development of a Virtual Reality System to support Reminiscence Therapy for Patients with Dementia

R5: Final Engineering Report

Team Members

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Capstone Coordinator (Winter 2020): Dr. Q. Mahmoud

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2. Executive Summary (1 %)

Dementia is an overall term for disease and conditions characterized by a decline in memory, language, problem-solving and other thinking skills that affect a person's ability to perform everyday activities [3].

There are currently no novel software solutions to help health-care professionals help patients with dementia. Because reminiscence therapy is a very important treatment, there are numerous benefits of designing software solutions to be used for reminiscence therapy. We have built a novel software solution in conjunction with Ontario Shores Center for Mental Health Science.

Ontario Shores for Mental Health Science is a public hospital in Whitby, Ontario that provides treatments for a wide range of mental issues. The geriatric dementia ward is the unit that we worked closely with.

The goal of the software solution was to help streamline, and assist staff with pre-existing reminiscence therapy. Our main focus was on the front-end side, where we present media files in a visually pleasing manner, and can cast wirelessly be seen on TVs, projectors and external monitors.

Throughout the semester we have worked in tandem with Ontario Shores, and have fulfilled all the requirements given to us, throughout the development process. We are now confident that we can go into the production phase.

4. R1 (0%)

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ENGR 4940U Capstone Systems Design for ECSE I

Design and Development of a Virtual Reality System to support Reminiscence Therapy for Patients with Dementia

R1: Project Identification, Research and Requirements Specification

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1. Problem Identification

The scope of this project is to design and implement a reminiscence therapy [2][3] system, addressing two needs of Ontario Shores Centre for Mental Health Sciences. The first need is a reminiscence system for general spaces, this will be used to create an atmosphere and make patients feel they are in a specific setting, for example a restaurant or an office. This will be achieved using a projector in a common space the patients gather in.

The second need is for personal reminiscence therapy for each patient, this includes personal photos, videos, audio files, and music[4]. This will be shown to patients using a portable system which can be taken to patient rooms or used in a dedicated therapy room.

2. Background and Research Review

Reminiscence Therapy today for the most part makes use of physical media. Photo albums and physical media players may be effective for patients suffering from dementia, however the question can be asked: Will a more immersive approach to reminiscence therapy be beneficial to patients suffering from moderate to severe dementia?

Digitizing of reminiscence media has begun on a small scale using portable devices such as iPads and TVs, however the devices requires constant interaction and manual operation. Patients suffering from moderate to severe dementia are prone to agitation and may not be comfortable having to constantly interact with a reminiscence system.

3. Design Process

The design process chosen for capstone project is the agile method [1], as shown in Figure 3.1.

Agile development is a great method for collaborative design. This model fits our project needs as Ontario Shores was unsure in their requirements and use cases. In the early meetings with Sheri, the project representative from Ontario Shores, we worked with her for gathering requirements as the technology and ideas are very new to the facility. This works with our

agile development process as it allowed us to design, develop, and test numerous scenarios for our project. On a conference call with multiple stakeholders we did a virtual deployment of our project where the stakeholders gave us their feedback on aspects of the project where they felt were good and bad. From there we then further refined our requirements and are back at the design and develop phase.

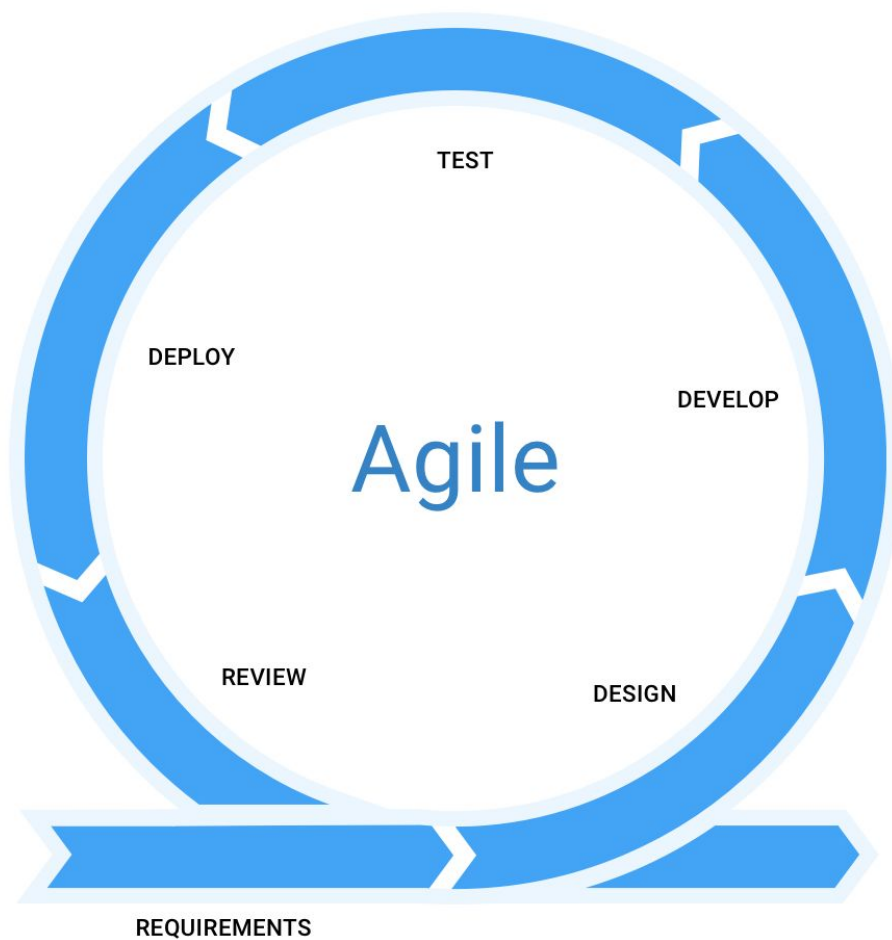## Agile model

Figure 3.1: Stages of agile development (Illustration by NATALIIA PETERHERIA, ProductTribe)

4. Scenarios and Use Cases

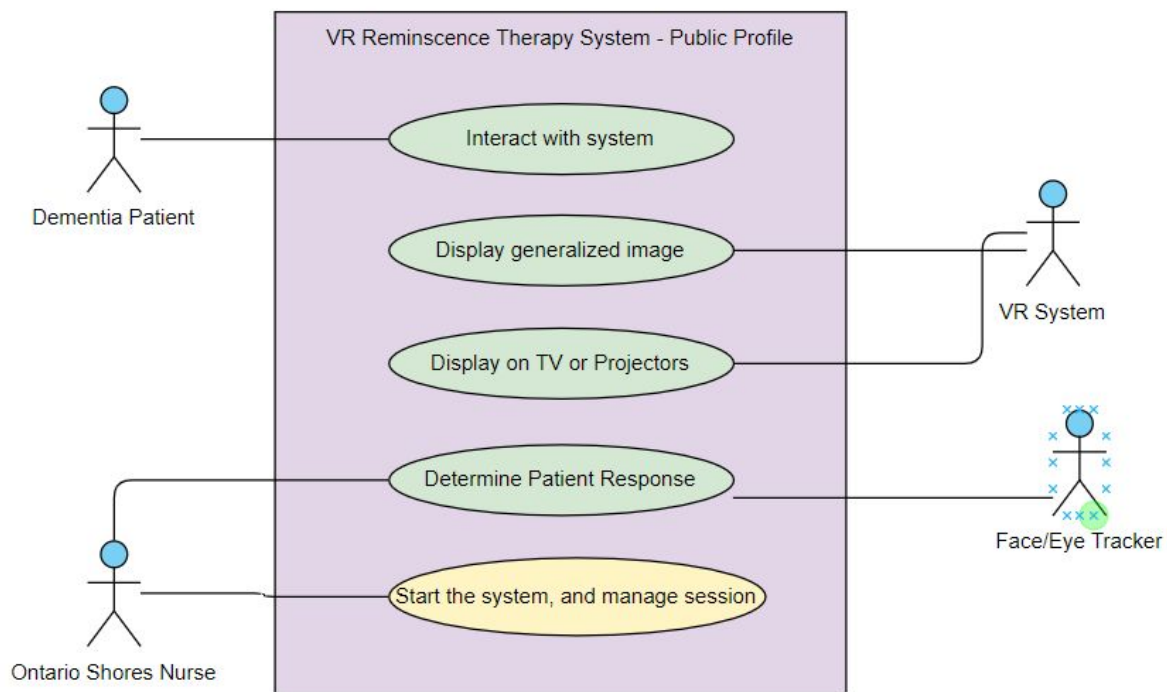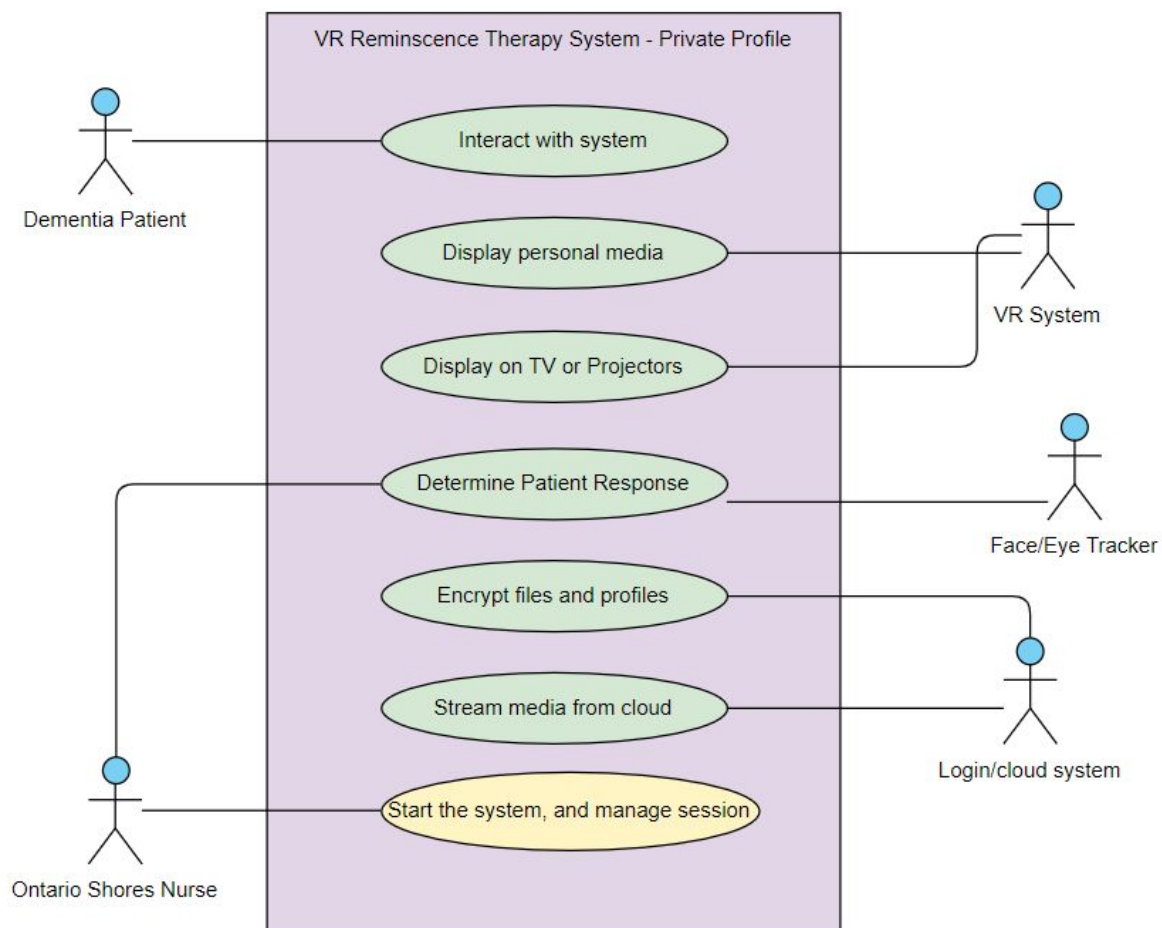Figure 4.1: Use case of general profile being displayed

Figure 4.2: Use case of Private profile being displayed

5. Stakeholder Requirements and Traceability Matrix

This capstone project includes many stakeholders. The following tables show the different types of stakeholders, the role each stakeholder play, and the needs and requirements of each stakeholder. To note, facilitating stakeholders are the capstone project group members, including the faculty advisor.

Table 5.1: Needs and Requirements of Stakeholders

Stakeholder List	Stakeholder Role	Stakeholder Needs and Requirements
Dementia Patients	· Test and use VR system for therapy	· Most patients cannot wear VR hardware · Cannot have system last more than 15 minutes
Patient Caregivers	· Supplement Therapy by being a good support group · Provide answers to therapy questions	· Needs to have privacy/information protected

Ontario Shores Center for Mental Health Science	· Main contact between patients and facilitating stakeholders · Test effectiveness of Capstone Project	· Immersive experience using projectors, TVs, VR hardware · Public Profile to be used in public setting · Private profile used for individual therapy sessions · Facial and/or Eye tracking to determine response from patients
Investors	· Provide funds for the project · Set return on investment and profitability	· Market-ready, profitable and return on investment with minimal risk · Well understood and manageable risk for revenues and lifetime · Maintain reputation to ensure future market share as investor · Get good press
University Faculty and Staff	· Review how capstone project could impact university	· Get good press · Integrate project with other faculties to have a cross-disciplinary project

Health and Safety Regulators	· Reviews project for health or safety impact · Grants authorization and approves project for avoiding health and safety impacts · Prosecutes for violation of health and safety laws	· Regulatory requirements are met for health and safety impact
Environmental Regulators	· Reviews project for environmental impact · Grants authorization and approves project for avoiding environmental impacts · Prosecutes violation of environmental laws	· Regulatory requirements are met for environmental impact
Other Regulators	· Reviews project for compliance with other regulations (e.g., working conditions)	· Other regulatory requirements are met
Economic Development Agencies and Policymakers	· Facilitate VR System project Development	· Positive societal impact in their area, such as tax revenue, jobs generation · Acceptable environmental impacts
General Public and Society	· Lobbies for or against the Capstone project	· Positive impact for society

		· Acceptable environmental impacts

As shown in the above table, 10 different groups of stakeholders have been identified, and each stakeholder role and requirements were identified.

6. Definition of Acceptance Tests

There will be a number of different acceptance tests that will eventually be refined and executed to demonstrate that the product has met the requirements.

1) Add different profiles for each patient
2) Each profile has to be secure and safe
3) Administrative privileges should only be given to select people
4) Generalized media will play when in group setting
5) Personalized media will play when alone
6) Eye tracking to monitor patient responsiveness
7) Multiple user login

7. Project Plan

The project will be split between two semesters. Requirements gathering and initial prototype will be done during the first semester. Meanwhile the final product deployment will be done in the second semester. Detailed plan included below.

Table 7.1 Project schedule

Task	Start date	(Tentative) Finish date
Progress Report 1	2019-09-15	2019-10-24
Project topic	2019-09-15	2019-09-20
Background research	2019-09-21	2019-09-27
Stakeholders requirement	2019-15-09	2019-10-11
Planning	2019-10-06	2019-10-19
Finalize report	2019-10-17	2019-10-24
Progress Report 2	2019-10-25	2019-11-14
Finalize budget	2019-11-07	2019-11-08
Developing Prototype	2019-10-12	2019-11-29
Design	2020-01-10	2020-02-01
Develop	2020-01-15	2020-02-15
Testing	2020-02-01	2020-02-19
Touch ups and finalization	2020-02-19	2020-03-21
Capstone Presentation	TBD	2020-04-10

8. Contribution Matrix

The list of tasks and contributors are shown in Table 8.1.

Table 8.1: Contribution matrix

Task	People			
	Abdurrahman Ansari	Mohammed Hameeduddin	Dhanushga Lionel	Mingwei Zhang
Requirement Gathering	25%	25%	25%	25%
Creating Scenarios	25%	25%	25%	25%

Writing use Cases	25%	25%	25%	25%
Report 1	25%	25%	25%	25%

References

List of references should be formatted using one of the referencing styles: APA or MLA or **IEEE**. All references should be cited within the report.

[1] Peterheria, N. (2019, September 7). Make Your Startup Work With Agile SDLC Model. Retrieved October 24, 2019, from https://producttribe.com/project-management/agile-sdlc-guide.

[2] Woods, B., Spector, A., Jones, C., Orrell, M., & Davies, S. (2005, April 18). Reminiscence therapy for dementia. Retrieved October 24, 2019, from https://www.ncbi.nlm.nih.gov/pubmed/15846613.

[3] Woods, B. (2018, March 1). Reminiscence therapy for dementia. Retrieved October 24, 2019, from https://www.cochrane.org/CD001120/DEMENTIA_reminiscence-therapy-dementia.

[4] Klever, S. (2013, April). Reminiscence therapy: Finding meaning in memories : Nursing2019. Retrieved October 24, 2019, from https://journals.lww.com/nursing/FullText/2013/04000/Reminiscence_therapy__Finding_meaning_in_memories.11.aspx.

[5] Li, M., Lyu, J.-H., Zhang, Y., Gao, M.-L., Li, W.-J., & Ma, X. (2017, December). The clinical efficacy of reminiscence therapy in patients with mild-to-moderate Alzheimer disease: Study protocol for a randomized parallel-design controlled trial. Retrieved October 24, 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5758240/.

5. **R2 (0%)**

Faculty of Engineering and Applied Science

ENGR 4940U Capstone Systems Design for ECSE I

Design and Development of a Virtual Reality System to support Reminiscence Therapy for Patients with Dementia

R2: Concept Generation, Conceptual Design and Prototype

Team Members

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1. Concept Generation and Analysis

Our main project function is to wirelessly stream media content to a display device from a media server using a webpage portal. The main components in our project are the user interface, database query, and stream service. Our main focus is working on a system that can wirelessly connect a computer to a display device.

There are two ways to solve this problem:

1. Create media streaming device
2. Explore existing off the shelf solutions.

Creating a new media streaming device using computer hardware such as a Raspberry Pi, would serve as a solution. A factor we have to also consider in longevity, our solution as a whole needs to be able to perform without failure. If a failure were to occur, the user would need to understand how to diagnose or even troubleshoot the program. If we continued with creating our own streaming device then the troubleshooting and maintenance would be problematic in the future.

The advantages of using an off the shelf solution are:

1. Existing technology is already developed by big companies and tested for failure
2. For popular solutions there are many guides and tutorials available online
3. Products come with the manufacturer's warranty and support incase of failure.

After discussing and weighing our different options we have decided to go with an off the shelf solution for our media streaming component. We will be integrating the functionality of the Google Chromecast with the web portal that will be used to query the database. The web portal will be created by us and will be projected to whichever display device the user selects.

The figure below details how our project components will interact with each other.
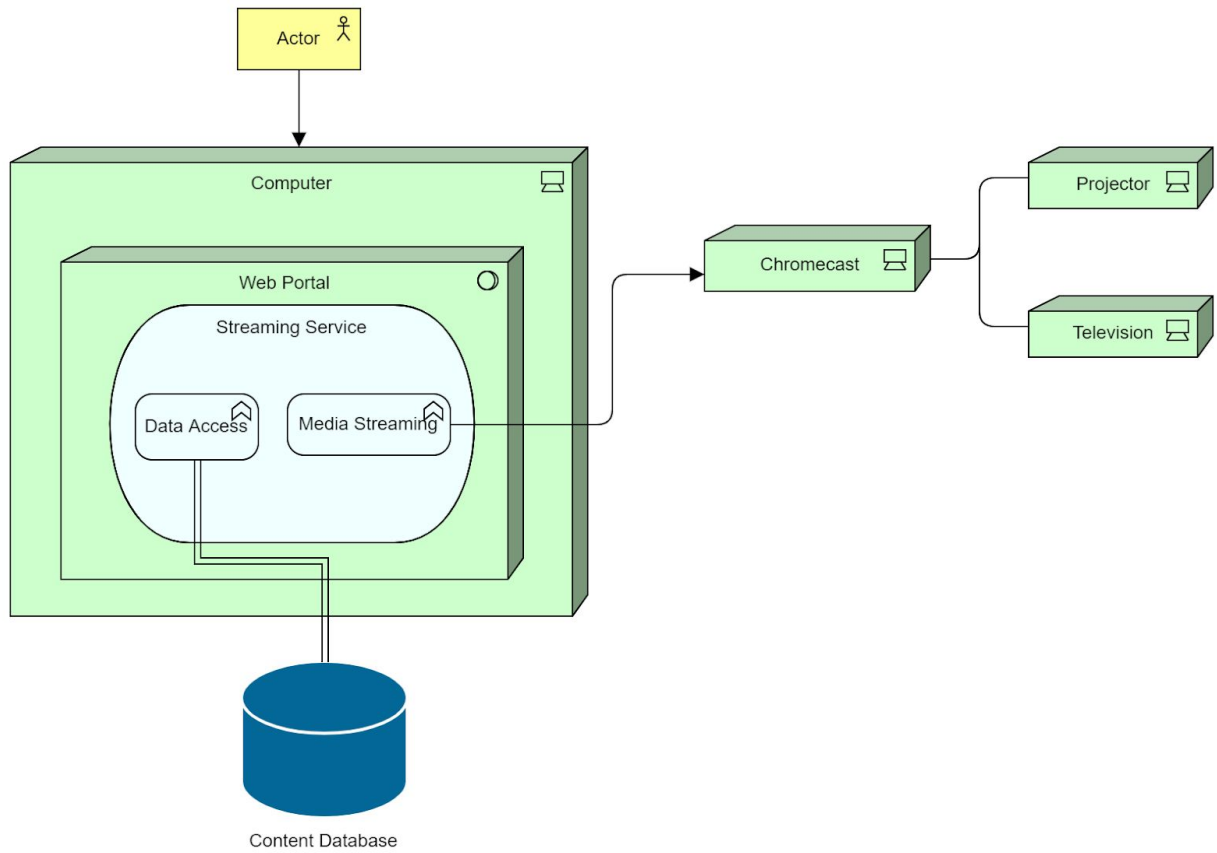
Figure 1.1 Relational Model

VR Reminscence Therapy System - Private Profile

- Dementia Patient — Interact with system
- Display personal media — VR System
- Display on TV or Projectors — VR System
- Determine Patient Response — Face/Eye Tracker
- Encrypt files and profiles — Login/cloud system
- Stream media from cloud — Login/cloud system
- Ontario Shores Nurse — Start the system, and manage session
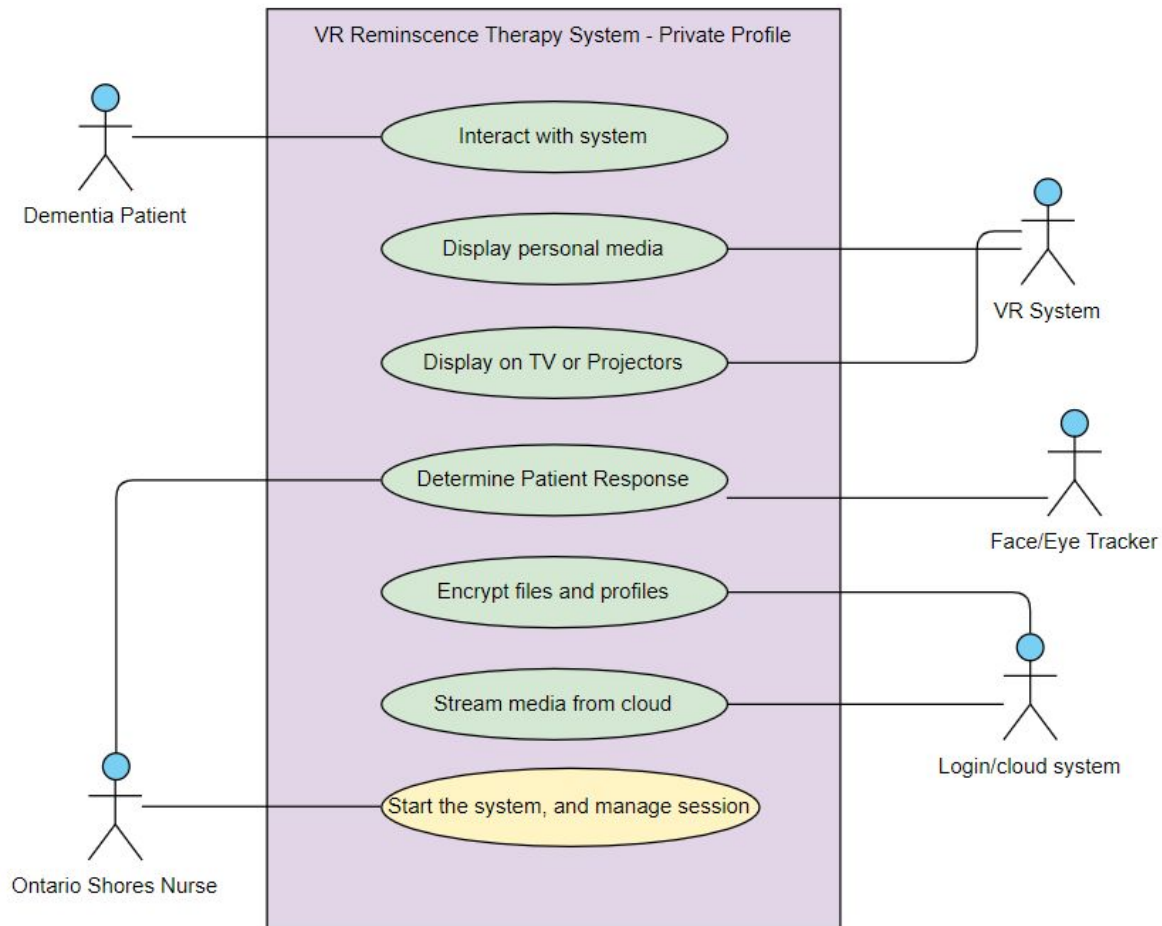
Use Case	Description
UC-1	Users, such as nurses, administrators and caregivers of the patients need to interact with the system
UC-2	The VR system needs to display the general profile
UC-3	VR system should push content onto a projected surface or tv using a chromecast or similar device
UC-4	Ontario Shores Personnel, whether it be nurses, or administrators, needs to be able to start the system, and manage session
UC-5	VR System needs to display personal profiles

	of each individual patient
UC-6	User needs to login to the system, using 2-factor authentication for extra protection
UC-7	Media files need to be compressed, and encrypted
UC-8	Profiles should be able to be streamed from a cloud database

Quality Attributes

ID	Quality Attribute	Scenario	Associated Use Case	Priority
QA-1	Performance	- Multiple users needs to be able to access system, without any data loss - System should be scanned periodically for errors so as to not cause shut-down	UC-1, UC-6	H,H
QA-2	Modifiability	New profiles should be able to be accessed, without system crashing	UC-1, UC-6	M,M
QA-3	Availability	In case of failure, system can shut down and restart	All	H,H
QA-4	Usability	- Profile user can access should be displayed. System should be fast and capable of making quick changes - Easy interface for everyone to be able to use	UC-4	H,M
QA-5	Security	If changes are made to the	All	H,H

		system, it is possible to know which user made the change		
		● If there is any unauthorized access, system should know		
		● If any user is logging in, 2-factor authentication, needs to be implemented		
		● If any user uploads media files, files should be safe from security breaches		
		● System should be safe from critical junction of merging both projects		

Constraints

ID	Constraints
CON-1	Multiple users should be able to login, and use system at the same time without failure
CON-2	Relational database needs to be used
CON-3	Changes made should be stored for data recovery purposes
CON-4	Nurse/Administrator should be able to access all profiles, and can stream both public and private profiles
CON-5	Private Wi-fi network, so chromecast cannot be used by unauthorized persons
CON-6	Systems shall not allow users to change information maintained by secondary systems

Architectural Concerns

ID	Concern
CRN-1	Establish overall system structure
CRN-2	Leverage team vast programming knowledge, and various programming languages
CRN-3	Allocate work to members of development team

Iteration 1

ADD Step 1: Review Inputs

Category	Details
Design Process	This is a greenfield system from a novel domain. The purpose is to produce a sufficiently detailed design to support the construction of the system.
Primary Functional Requirements	From the uses cases presented from the first iteration, the primary uses cases are ●
Quality Attribute Scenarios	<table><tr><td>Scenario ID</td><td>Importance to Stakeholders</td><td>Difficulty of implementation</td></tr><tr><td>QA-1</td><td>High</td><td>High</td></tr><tr><td>QA-2</td><td>Medium</td><td>Medium</td></tr><tr><td>QA-3</td><td>High</td><td>High</td></tr><tr><td>QA-4</td><td>High</td><td>Medium</td></tr><tr><td>QA-5</td><td>High</td><td>High</td></tr></table>

	Only QA-1, QA-3, QA-4, QA-4, QA-5 were selected as drivers
Constraints	All constraints discussed in first deliverable are included as drivers
Architectural Concerns	All the architectural concerns discussed in first deliverable are included as drivers

Iteration 1:

This first iteration of the system is to establish an overall system structure

Step 2: Establish Iteration Goal by Selecting Drivers

This is the first iteration in the design of the system, so the goal of this iteration is to *establish an overall system structure*.

Although this iteration is driven by a general architectural concern, the developer must keep in mind all of the drivers that may influence the general structure of the system. In particular the developer must be mindful of the following:
- QA-1: Performance
- QA-3: Availability
- QA-4: Usability
- QA-5: Security
- CON-1: Multiple users without server failure
- CON-2: Relational database

Step 3: Choose one or more elements of the system to refine

This is a greenfield development effort, so in this case, the element to refine is the entire system, which is shown in Figure 1. In this case, refinement is performed through decomposition.

Figure 1: Context diagram for system

Step 4: Choose one or more design concepts that satisfy the selected drivers
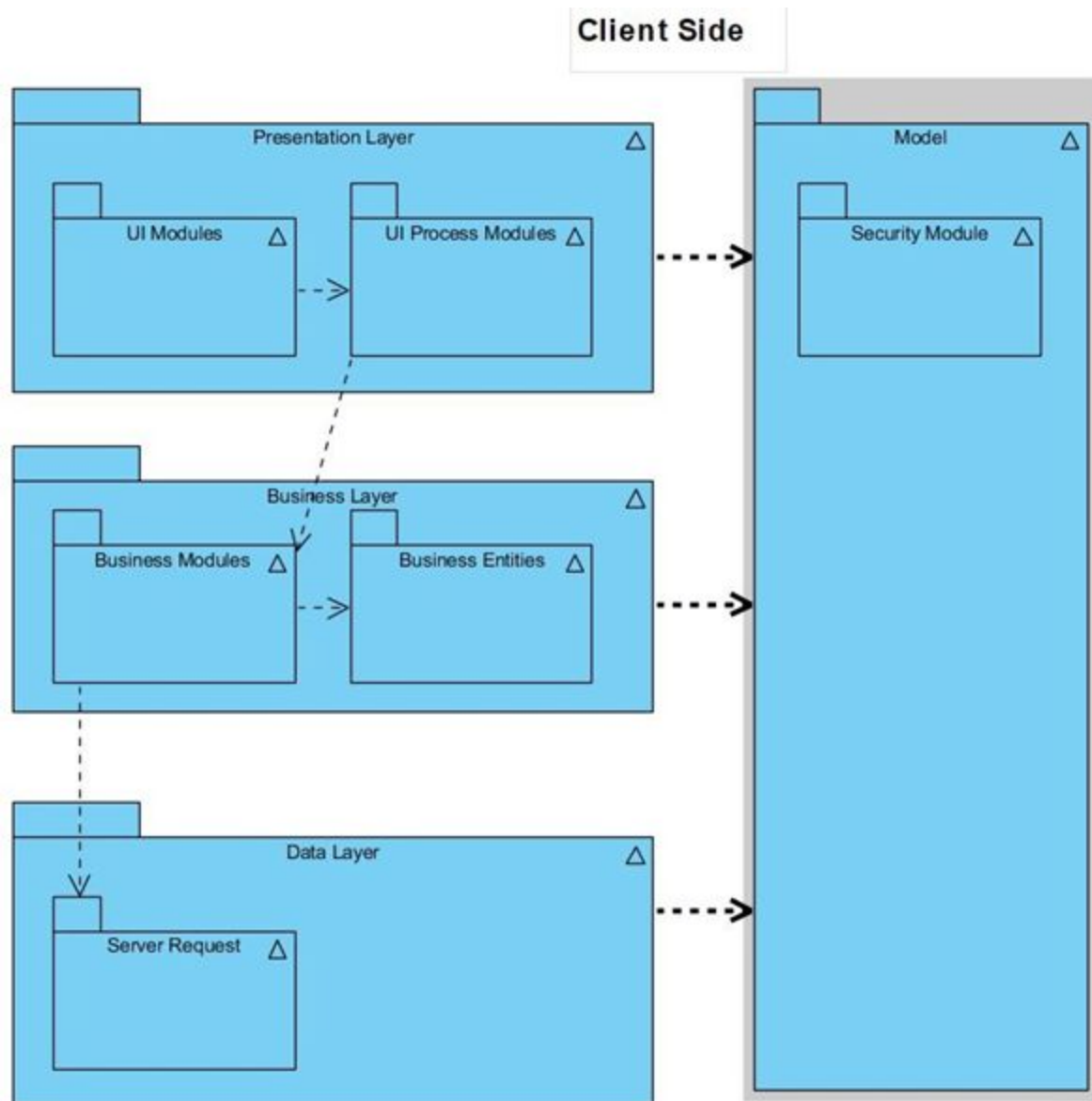
Design Decisions and Location	Rationale
Logically structure the client part of the system using a web application reference architecture	This type of reference architecture must be accessed from a web browser, such as examples of Netflix. This is the best option to implement the client part of the system because it has a User Interface, Business Logic and Data Access, which is what we need for this project. Discarded Alternatives: ● Mobile Application: This type of architecture is only geared towards development of applications that are deployed in handheld devices. This alternative was discarded because this type of device was not considered for the System. ● Rich Internet Application: This reference architecture is oriented toward the development of applications with a rich user interface that runs inside a web browser. This option was discarded because there was no plugin to run the application. The plugins are used to access the options in the application itself.
Logically structure the server part of the system using Service Application reference architecture.	Service application expose services that are consumed by other application. The Service Application was the best reference architecture to meet the requirements.
Physically structure the application using the Three-tier deployment pattern	Since the system is accessed from a web browser, we need to have a database server. Therefore the three-tier deployment is the most appropriate
Build the user interface of the client application using HTML/CSS and JavaScript	Best to make a clean simple UI, that everyone can use, no matter their experience in technology. Therefore these languages are the best fit and meet the requirements

Deploy the application using AWS	AWS will be used to deploy the CMS system.

Step 5: Instantiate architectural elements, allocate responsibilities, define interfaces

Design Decision and Location	Rationale
Create a module dedicated to access the database of the Service Application reference architecture	The service agents component from the reference architecture is adapted to access the database. This will ensure the achievement of QA-1, QA-5 and QA-6.

Step 6: Sketch views, record design decisions

Client Side

Presentation Layer
- UI Modules
- UI Process Modules

Business Layer
- Business Modules
- Business Entities

Data Layer
- Server Request

Model
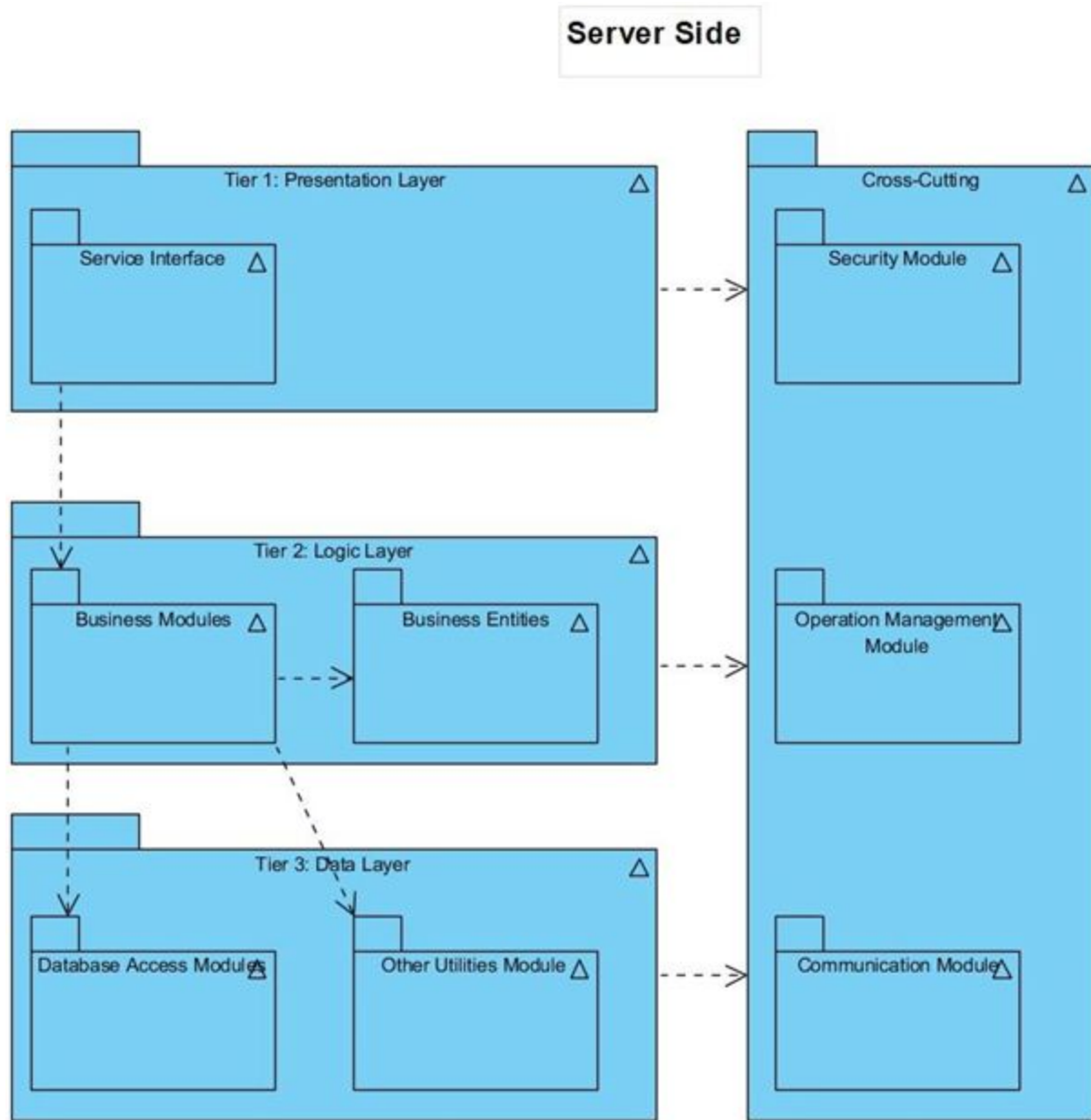- Security Module

Server Side

Figure 2: Client and Server side view of the system

Element	Responsibility
Presentation Layer (Client Side)	This layer contains modules that control UI and deals with input and output for

	users and communicates with the Business Layer
Business Layer(Client Side)	This layer contains modules that perform business logic operations that can be executed locally on client side. This layer also communicates with Data layer.

Data Layer (Client Side)	This layer contains modules responsible for communication with server, and store in database
UI Modules	Render for UI and receive inputs
UI Process Modules	Control flow of all system use case
Business Modules	Implement the business operations
Business Entities	Make up the domain model.
Server Request	Communicate with database to request information
Presentation Layer (Server Side)	This layer contains modules that expose services that are consumed by clients
Logic Layer (Server Side)	This layer contains modules that perform business logic operation that require processing from server side.
Data Layer (Server Side)	This layer contains modules that are responsible for data persistence and for communication

Service Interface	Modules expose service that are consumed by clients
Business Modules	Implement business operations
Business Entities	Make up the domain model
Database Access Module	Responsible for persistence of business entities into the relational database. It performs object oriented to relational mapping and shields the rest of the application from persistent details.
Other Utilities Module	Implement other utilities of the data layer
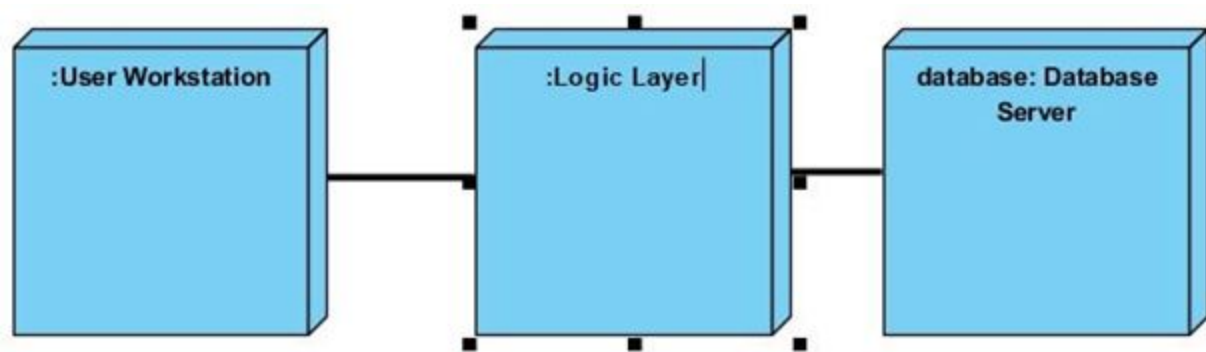
Figure 3: Initial deployment diagram of system

Element	Responsibility
User Workstation	User browser which host client side logic of system
Logic Layer	Communicating with user workstation and Database server

Database server	Host relational database

Relationship	Description
Between User Workstation and Logic layer	Any business logic that user has in interface is calculated here
Between Logic Layer and Database Server	Logic layer communicates with Database Server using SQl

Step 7: Perform analysis of current design and review iteration goal and achievement of design process

The following table summarizes the design progress using the Kanban board technique

Not Addressed	Partially Addressed	Completely Addressed	Design Decisions made during the Iteration
	UC-1		Selected Reference Architecture establish modules that will support this functionality.
	UC-3		Selected Reference Architecture establish modules that will support this functionality

	UC-4		Selected Reference Architecture establish modules that will support this functionality
	QA-3		Identification of elements derived from deployment pattern that will need to be replicated
QA-4			No relevant decisions made
	CON-1		3 Tier architecture was used to support multiple users to connect to business layer. Decisions for concurrent access has not been made yet.
		CON-2	Database layer from three tier architecture was used so relation database could be created. Can access the database from data layer of architecture.

CON-3			No relevant decisions made
CON-4			No relevant decisions made
CON-5			No relevant decisions made
CON-6			No relevant decisions made

Iteration 2

ADD Step 1: Review Inputs

Category	Details
Design Process	This is a greenfield system from a novel domain. The purpose is to produce a sufficiently detailed design to support the construction of the system.
Primary Functional Requirements	From the uses cases presented from the first iteration, the primary uses cases are •
Quality Attribute Scenarios	

Scenario ID	Importance to Stakeholders	Difficulty of implementation
QA-1	High	High

	QA-2	Medium	Medium
	QA-3	High	High
	QA-4	High	Medium
	QA-5	High	High
	Only QA-1, QA-3, QA-4, QA-4, QA-5 were selected as drivers		
Constraints	All constraints discussed in first deliverable are included as drivers		
Architectural Concerns	All the architectural concerns discussed in first deliverable are included as drivers		

Step 2: Establish iteration goal by selecting drivers

The goal of iteration 2 is to address the general architectural concern of identifying structures to support primary functionality. The developers consider the system primary uses cases:
- UC-1: Interact with the system
- UC-2 & UC-5: Push both public and private content onto projected services
- UC-3: Project profiles onto projectors/tvs using 3rd party hardware (ie. Chromecast)

Step 3: Choose one or more elements of the system to refine

The elements that will be refined in this iteration are modules located in different layers of the three tier web application, especially in the database and business logic layer. In general, the support of functionality in this system requires the collaboration of components associated with modules that are located in the different layers.

Step 4: Choose one or more design concepts that satisfy the selected drivers

In this iteration, several design concepts—in this case, architectural design patterns—are selected from the book Pattern Oriented Software Architecture, Volume 4. The following table summarizes the design decisions.

Design Decisions and Location	Rationale and Assumption
Create a **Domain Model** for the application	Before starting a functional decomposition, it

	is imperative to create an initial domain model for the system. This identifies major entities in domain, along with their relationships. There are no good alternatives. A domain model must eventually be created, or it will appear in sub/non-optimal fashion, leading to an ad hoc architecture that is hard to understand and maintain.
Identify **Domain Objects** that map to functional requirements	Each distinct functional element of application needs to be encapsulated in self-contained building block which is a domain object. Another possibility is to not consider domain objects but directly decompose the layers into modules. However this will increase the risk of not considering a requirement.
Decompose **Domain Objects** into general and specialized **Components**	Domain objects represent complete sets of functionality. This functionality however is supported by finer-grain elements located in within the layers. The "components" in this pattern are called modules.

Step 5: Instantiate architectural elements, allocate responsibilities, and define interface

Design Decisions and Location	Rationale
Create only and initial domain model	The entities that participate in the primary uses cases need to be identified and modeled but only an initial domain model is created. This is to accelerate this phase of the design.
Map the system uses cases to domain objects	An initial identification of domain objects can be made by analyzing the system's use cases. To address CRN-3, we identify domain objects for all use cases presented in iteration 1
Decompose the domain objects across the layers to identify layer-specific modules with explicit interface	This technique ensures that modules that support all the functionalities are identified. The architect will perform this task just for the primary use cases. This will allow another team member to identify the rest of the modules, thereby allocation work among team members. After establishing a set of modules, the architect realizes the need to test these modules. So a new architectural concern is identified. ● CRN-4: Need to test a majority of the modules Only a majority of the modules are covered by CRN-4 because the modules that implement the UI is difficult to test independently.

Step 6: Sketch views and record design decisions

As a result of the decisions made in step 5, several diagrams are created.
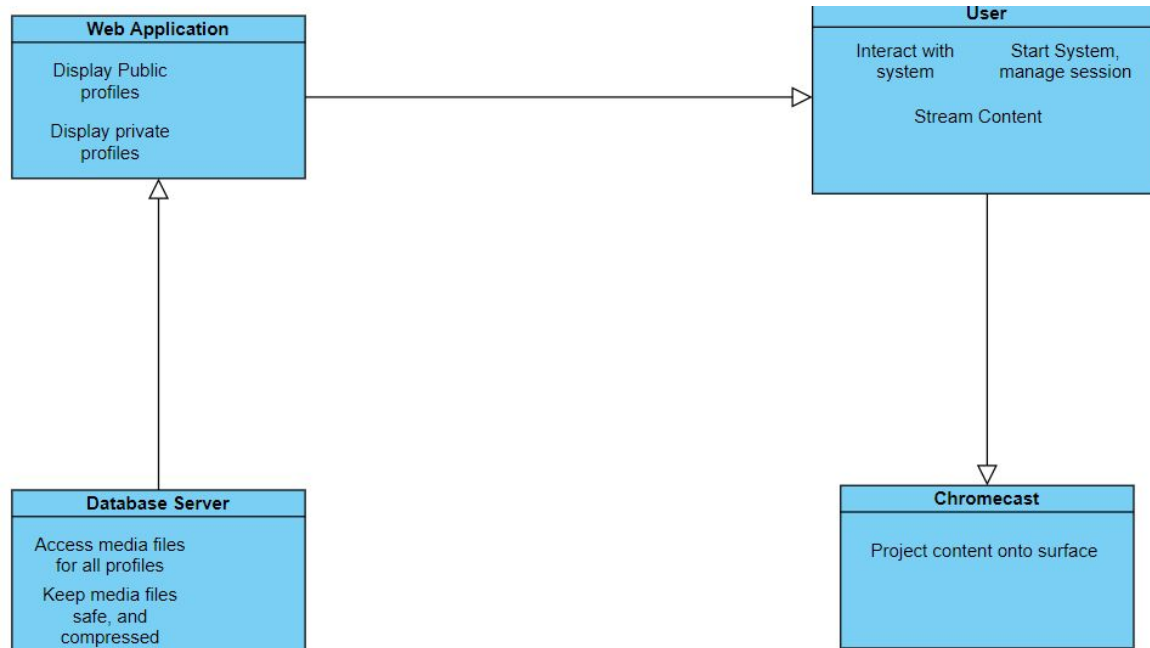
Figure - Initial Domain Model
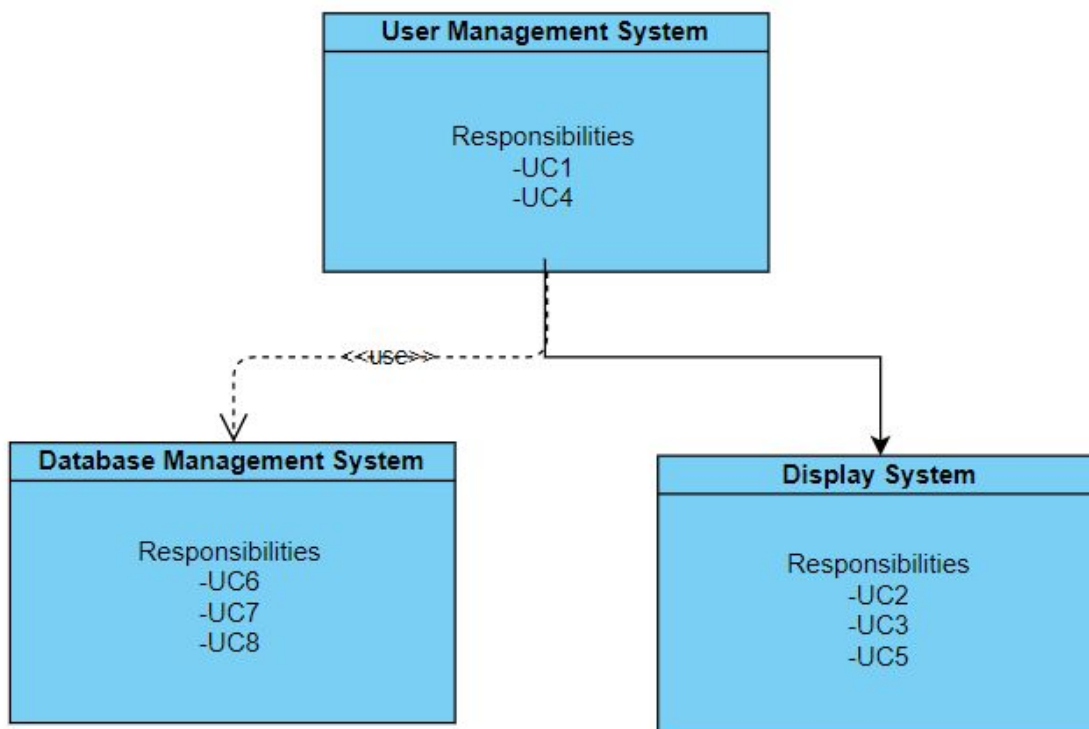
Figure- Domain objects associated with the use cases
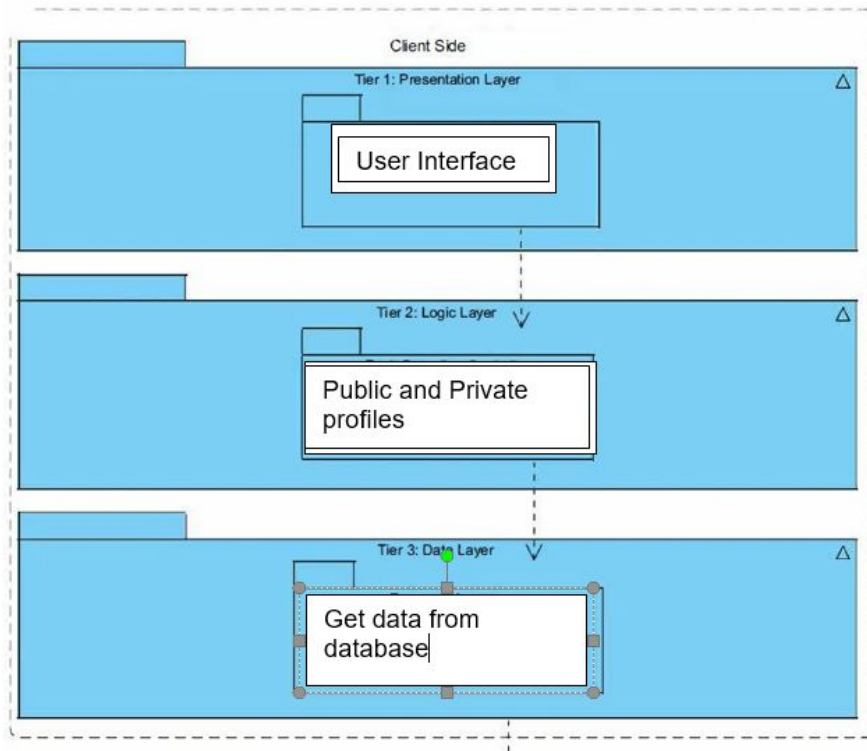
Figure - Modules that support the primary use cases

Elements	Responsibility
User Interface	This will be the place where users (staff), can interact with the system
Logic Layer (Public and Private profiles)	This will show the public and private profiles. Media files can be searched by tags. Also image processing algorithms can be used to sort images.
Data Layer	This will be the database that will store the media files.

Figure - Sequence Diagram for Use Cases 1, 2, 3, 4 & 5

The figure above shows the sequence diagram for uses cases 1, 2, 3, 4 and 5. When the staff first logs in, they will interact with th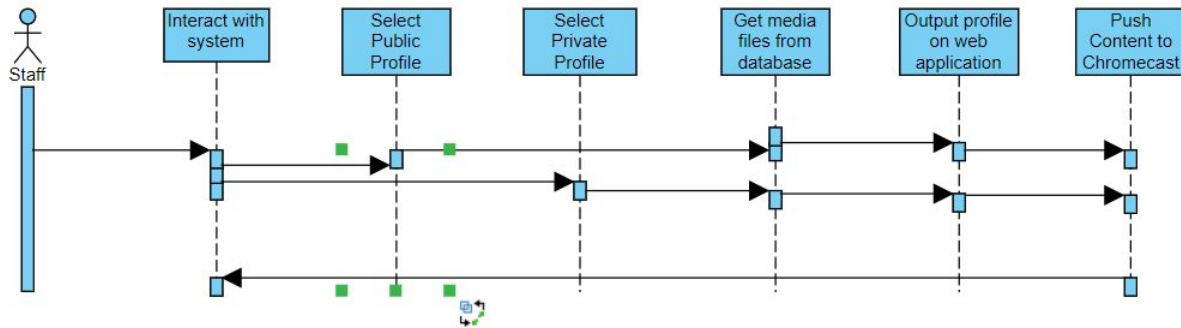e system. User will have the option to select the public or private profiles. Whatever actions will dictate what media files to query from the database. The media files will be then shown on the web application. After this the content can be pushed from the web application, to a projector or TV using the ChromeCast. The user can then interact with the system, by starting/stopping slideshow, or start audio stream etc.

Name	Description
System Interaction	User (staff) will need to login to the system. They can also start or stop the system, push the content to the projector, start slideshow etc.
Public Profile	Users can pick a public profile which will be used in a group setting session.
Private Profile	Staff can select a personal patient profile, which will be used for an individual therapy session.
Database Query	When a specific profile is chosen, the database will be queried, and will search for the media files associated with that profile.
Web Application Display	After the media files have been chosen, they will be displayed to the web page.
Chromecast to wirelessly display	Users can stream the web page wirelessly to a projector or TV.

Step 7: Perform analysis of current design and review iteration goal and achievement of design process

Established	Not Established	Partly Established	Design Decisions made during Iteration
UC- 1			Interfaces and modules have been identified in relation to this use case
UC-2			
UC - 3			Interfaces and modules have been identified in relation to this use case
UC - 4			Interfaces and modules have been identified in relation to this use case
UC-5			
		QA-1	Many users can use system concurrently

		QA-3	If a failure of malfunction does occur, the system has been designed to shutdown and restart.
		QA- 4	Data is queried from database.
	QA- 5		Design decisions have not been made in this iteration
	CON -1		Design decisions have not been made in this iteration
CON -2			Servers have been established in order to use system databases for the system
		CON -3	Design decisions have been made, ,but need expansion
CON -4			Modules for users to access data for all profiles have been established.

		CON - 5	Design decisions have not been made for this iteration.

		CON-6	Design decisions have not been made in this iteration
	CRN -1	CRN -1	Architecture has been established and needs more implementation
CRN -2			Programming language is chosen by the average familiarity with the language in accordance of the team
CRN -3			Workload has been divided.

Iteration 3

ADD Step 1: Review Inputs

Category	Details
Design Process	This is a greenfield system from a novel domain. The purpose is to produce a sufficiently detailed design to support the construction of the system.
Primary Functional Requirements	From the uses cases presented from the first

	iteration, the primary uses cases are ●
Quality Attribute Scenarios	<table><tr><td>Scenario ID</td><td>Importance to Stakeholders</td><td>Difficulty of implementation</td></tr><tr><td>QA-1</td><td>High</td><td>High</td></tr><tr><td>QA-2</td><td>Medium</td><td>Medium</td></tr><tr><td>QA-3</td><td>High</td><td>High</td></tr><tr><td>QA-4</td><td>High</td><td>Medium</td></tr><tr><td>QA-5</td><td>High</td><td>High</td></tr></table> Only QA-1, QA-3, QA-4, QA-4, QA-5 were selected as drivers
Constraints	All constraints discussed in first deliverable are included as drivers
Architectural Concerns	All the architectural concerns discussed in first deliverable are included as drivers

Iteration 3: Addressing Quality Attribute Scenario Driver (QA-3)

This section presents the results of the activities that are performed in each of the steps of ADD in the third iteration of the design process. Building on the fundamental structural decisions made in iterations 1 and 2, we can now start to reason about the fulfillment of some of the more important quality attributes. This iteration focuses on just one of these quality attribute scenarios

Step 2: Establish iteration goal by selecting drivers

For this iteration 3, the developers focused on QA-3 quality attribute scenario. A failure occurs in the system during an operation. The system will need to shut down and restart immediately.

Step 3: Choose one or more elements of the system to refine

For this particular scenario, the elements that need to be refined are:

- Application Server

- Database Server

Step 4: Choose one or more design concepts that satisfy the selected drivers

Design Decisions and Location	Rationale and Assumption
Introduce active redundancy, by replication application server and other critical components such as database.	When replicating these critical elements, the system can withstand the failure of one of the replicated elements without affecting functionality.
Backup database regularly	In case the database server crashes, due to malfunction or such. Having backuped data will ensure previous data, and prevent data loss.

Introduce element from **message queue** technology family	Traps received from time servers are placed in the message queue and then retrieved by the application. Use of a queue will guarantee that traps are processes and delivered in order (QA-1)

Step 5: Instantiate architectural elements, allocate responsibilities, and define interfaces

The instatintion design decisions are summarized in the following table:

Design Decisions and Location	Rationale
Deploy Message queue on separate node	Deploying the message queue on separate node will guarantee that no traps are lost in case of application failure. This node is replicated using the tactic of active redundancy, but only one copy receives and treats events coming from the CMS system.
Use active redundancy and load balancing in the application server	Load balancer needs to be deployed to regulate traffic for multiple application server. This will introduce a new architectural concern CRN-4: Manage states in replicas.
Implementing load balancing and redundancy using support	There are many technological options for load balancing and redundancy that can be implemented without having to develop ad hoc solution that is harder to support and less mature

Step 6: Sketch Views and Record Design Decisions

Figure 1 shows the refined deployment diagram that includes the introduction of redundancy in the system.
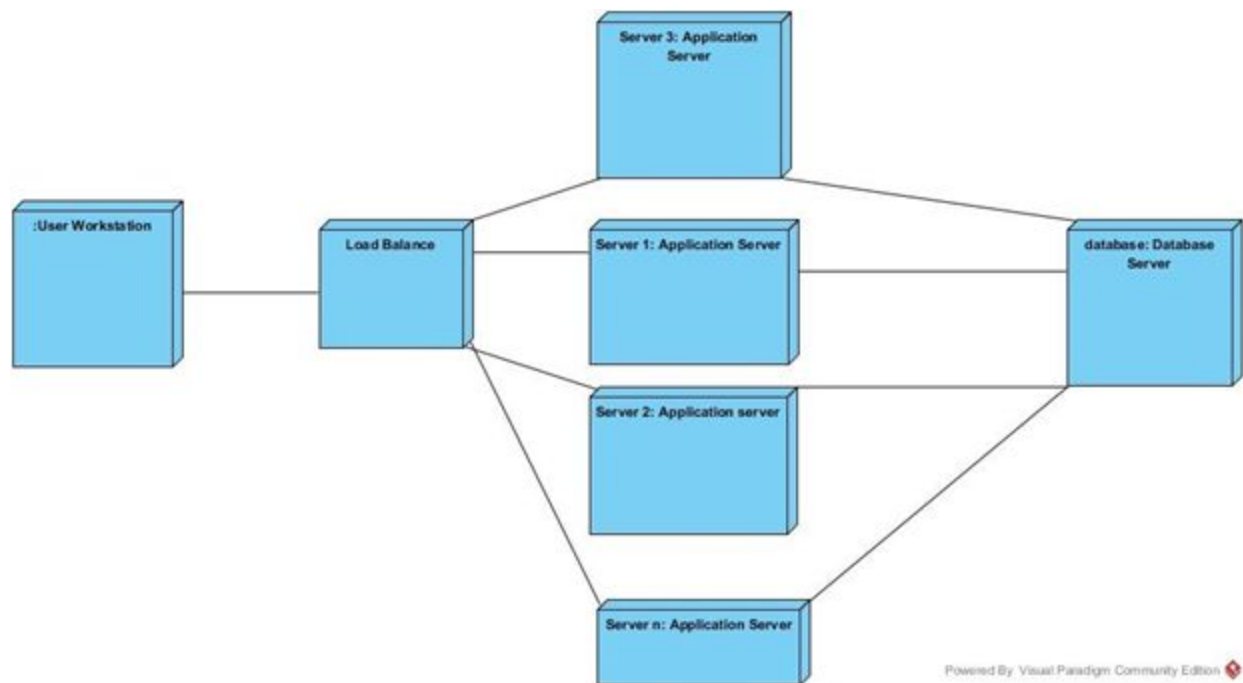
Figure 1: Deployment Diagram

Element	Responsibility
Load Balance	Takes the requests coming from users to application servers.
Database Server	Takes control of all the databases needed for the system.

Step 7: Perform analysis of current design and review iteration goal and achievement of design purpose

Established	Not Established	Partly Established	Design decisions made during iteration
QA-1			Performance of system should be scanned periodically to prevent any malfunctions. Also

			data should be logged at certain intervals to prevent data loss, if performance is suffering due to data loss.
QA-5			System for tracking by user ID has been established
CON-1			Multiple servers are established a co-related through a database to improve flow of traffic and maintain load.
CON-3			Database has been established for data recovery
CON-6			Restriction and security protocols are established for secondary systems

2. Conceptual System Design

The reminiscence therapy system consists of a database, a web portal, and a media playing device. The web portal accesses the data stored in the database based on who is logged in, the web portal also transmits data to a media playing device, in this case a ChromeCast. The basic layout of the system is displayed in the diagram below.
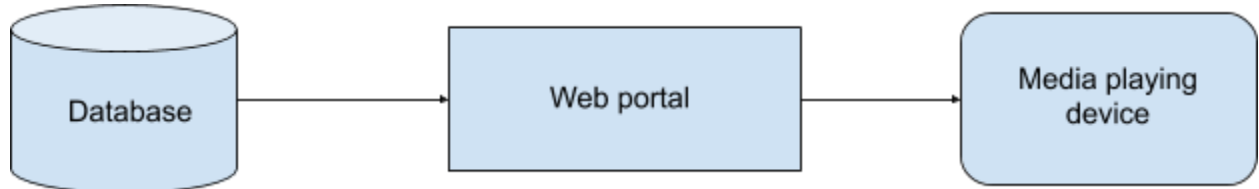

Figure 2.1 Basic Layout of System

The database will stream media including photos, videos, and audio files through the web portal to the ChromeCast whenever a user requests a stream. The transfer rate will be limited by the network the system runs on. The web portal allows users to view the media stored on the database, the users can see the names of files as well as thumbnails which preview the file's contents. The names and thumbnails are transferred to the web portal when a user logs in.

The database is used to store reminiscence media uploaded by caregivers and Ontario Shores employees. The web portal is used to access the media from the database, it is also used to send data to a ChromeCast. The ChromeCast is connected to a display (projector, T.V.) and used to display the media from the database to said display.

3. Definition of Integration Tests

The system consists of multiple parts which must work together in order to perform a specified task. At a higher level the system is split into large components dealing with data access and data display, since these 2 parts are modular they can be tested separately. We will employ the bottom-up approach to testing the system, ensuring the smaller parts are working correctly before they are merged as part of a larger system.

The data access portion deals with establishing a database connection, interfacing with the user, downloading the requested data, and uploading user data. The first test would be to establish a database connection, then we will need to test the upload and download functions. Once the database connection and methods are functioning as intended, the next step is to test the UI that users will interact with. The various functions provided by the UI including viewing the files belonging to the profile, uploading files, and displaying files will be tested.

The second part to be tested is the media display portion of the system. We would need to test the transmission of data wirelessly from a computer to a display, and also ensure that the requested data is being downloaded correctly.

Once both parts have been tested,we will test them together and ensure they interface correctly with each other.

4. Estimated Cost

Table 4.1 Time and Effort Estimation

Resource Skill Set	Development Timeline (in business days)
UI/UX	2
Web Developer 1	10
Web Developer 2	10
QA Testing	3
Database Engineer	5
Total Project Timeline/Cost	30

Table 4.2 Cost Estimation

Item	Quantity	Cost Per Unit (Pre Tax)
Optoma W412 Projector	2	$819.00
Google Chromecast	3	$45.00
Total		$1,773.00

COCOMO

This project will be an organic project, because our team size is small (4 people), the problem is well understood, and the team members have nominal experience in solving this type of problem. We estimate to have at most 1000 lines of code. We can estimate the basic model with the formula $E = a(KLOC)^b$. Using this model, and knowing the values for a and b being 2.4 and 1.05 respectiley, our estimate of person months is E = 2.4(1)^1.05, our estimate E = 2.4 person-months.

5. Updated Project Plan

The project will be split between two semesters. Requirements gathering and initial prototype will be done during the first semester. Meanwhile the final product deployment will be done in the second semester. Detailed plan included below.

Table 5.1 Project schedule

Task	Start date	(Tentative) Finish date	Actual Finish Date
Progress Report 1	2019-09-15	2019-10-24	2019-10-24
Project topic	2019-09-15	2019-09-20	2019-09-20
Background research	2019-09-21	2019-09-27	2019-09-27
Stakeholders requirement	2019-15-09	2019-10-11	2019-10-11
Planning	2019-10-06	2019-10-19	2019-10-19
Finalize report	2019-10-17	2019-10-24	2019-10-24
Progress Report 2	2019-10-25	2019-11-14	2019-11-14
Finalize budget	2019-11-07	2019-11-08	2019-11-14
Developing Prototype	2019-10-12	2019-11-14	2019-11-23
Design	2020-01-10	2020-02-01	2020-02-01
Develop	2020-01-15	2020-02-15	2020-02-01
Testing	2020-02-01	2020-02-19	2019-11-24
Touch ups and finalization	2020-02-19	2020-03-21	2019-11-27 - Presentation 1 TBA- Semester 2
Capstone	2019-11-28 - S1	2019-11-28 - S1	2019-11-28 -

| Presentation | TBD - S2 | 2020-04-10 - S2 | Semester 1

TBD Semester 2 |
|---|---|---|---|

6. Contribution Matrix

The list of tasks and contributors are shown in Table 6.1.

Table 6.1: Contribution Matrix

Members	People			
	Abdurrahman Ansari	Mohammed Hameeduddin	Dhanushga Lionel	Mingwei Zhang
Solution Research	25%	25%	25%	25%
System Design and Flow	0%	50%	25%	25%
UI Modelling	25%	0%	25%	50%
Report 2	30%	20%	30%	20%

6. Revised design report (4 %)

A number of new features were added to the capstone project. These changes were requested by Ontario Shores after a meeting with them in February.

A new gallery view has been added between the profile view and media display. In the gallery view, the pictures contained inside the selected album of the patient profile is displayed as a grid, as well as ability to select them for further manipulation. Inside the gallery view, the ability to move or copy images to another album, the ability to delete images from the album, and the ability to play from the middle of the album was added.
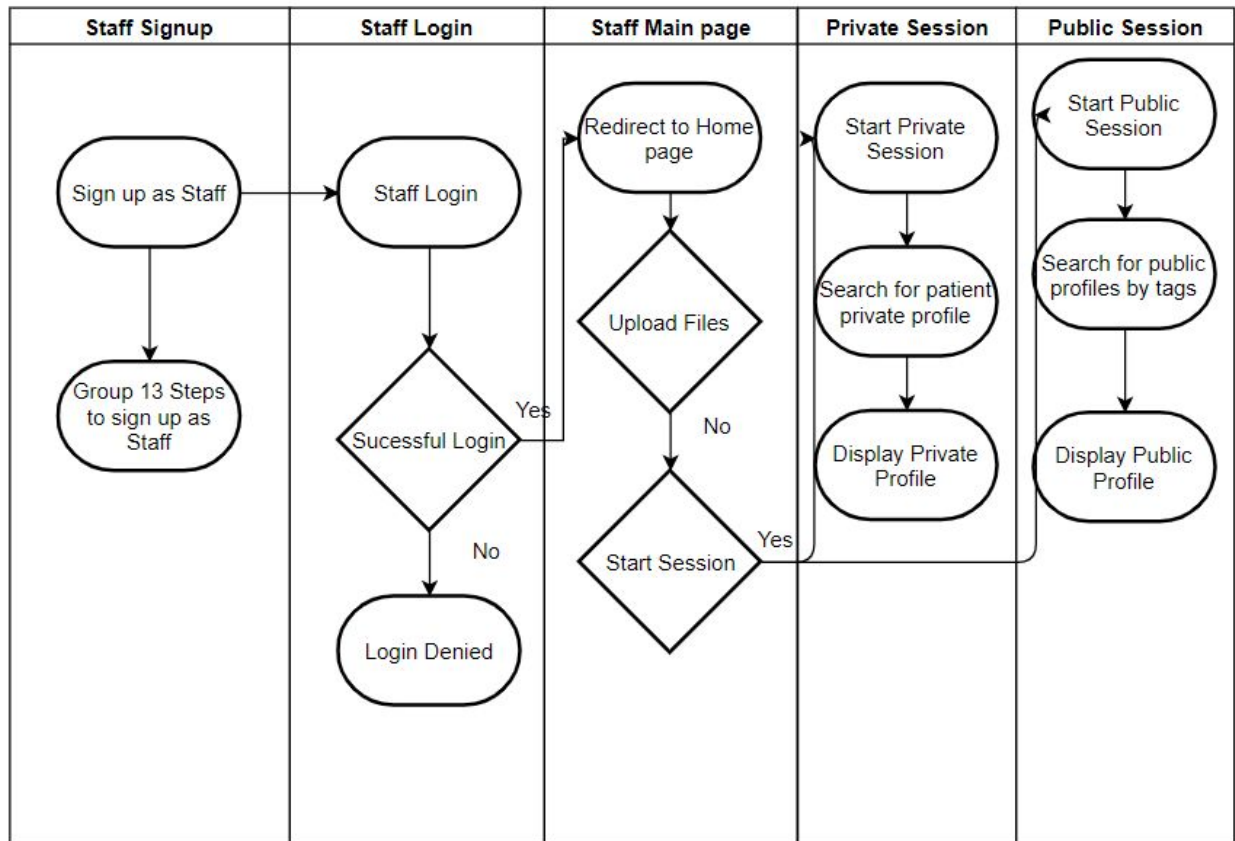
Figure: Activity Diagram for Staff starting the session

This activity diagram shows the steps for staff to start a private or public session. Firstly if the staff do not have an account, they can sign up, and go through the steps that Group 13 has detailed on in their respective report. If a staff member already has an account they can go to the login page. Staff will go through the steps detailed in Figure 1. Once successfully logged in, they will be redirected to the home page. Here the staff can choose to start a session, and will be given an option of starting a private or public session. The staff can start a private session if they are doing therapy for an individual patient. In a private session, the staff has access to the patients private profiles provided by the caregivers. The staff can also start a public session, for a group setting. Here the staff can access a public profile, by searching. Once the public profile is found, the staff can access the profile. They will be redirected to the slideshow module, which will automatically display pictures and videos of that profile. Audio files can also be played in the background. To display the session to a TV or projector, the staff needs to use a chrome web browser. They can then click on the settings and navigate to the 'Cast' feature, where they can select a Google Chromecast that they want to stream to.

7. Ethical Considerations (2 %)

This capstone project had many ethical considerations. This includes the protection of user data[1]. Because our application involves the use of personal and/or confidential data for each patient, diligence is required. Since these data are considered as medical documents, as they are used in a treatment capacity, we need to make sure we follow PIPEDA[2].

We also need to consider the ethical considerations to [1]:

Public: Our product needs to be in the best interest of the public

Stakeholder: Our product is in the best interest of the stakeholder which is consistent with public interest.

Product: Our product meets and exceeds the highest possible standards

Profession: Our product advances the integrity and reputation of the profession which is consistent with public interest

8. Safety Considerations (2 %)

The main focus of safety considerations for this project is the security of patient media. Patients, family members, and Ontario Shores staff will be uploading personal media that is meant to be private and only viewable from the associated patient's account. We must ensure the media uploaded by a patient's family or a staff member is stored in a secure location which cannot be accessed by unauthorized individuals. We must also ensure that the media is only accessible through authorized accounts so users of the platform cannot access media not related with their account.

9. Conclusions (1 %)

In conclusion, this capstone was very fun and was a resounding success. The students in this capstone project applied their theoretical knowledge from their degree, and applied it to a real-world project. The students also gained familiarity in agile development methods, in an industrial capacity.

10. Acknowledgements (1 %)

There are many people that were instrumental in getting this project off the ground. A huge thanks to our capstone supervisor, Dr. Liscano, for guiding us over the course of a school year, helping us utilize our education in an industrial project capacity.

We would also like to thank Sheri Horsburgh and Carmen for helping us, and giving great feedback, on how to improve our project.

In addition, Dr. Winne Sun, and Dr. Alvaro Quevedo, and their respective students, were excellent guides and resources on helping us understand this project.

11. References (1 %)

[1] Alcanja, Daniel. "Why We Need to Address Ethical Issues In Software Engineering." *Simple Programmer*, 9 Oct. 2019, simpleprogrammer.com/ethical-issues-software-engineering/.

[2] Office of the Privacy Commissioner of Canada. "The Personal Information Protection and Electronic Documents Act (PIPEDA)." *Office of the Privacy Commissioner of Canada*, 4 Sept. 2019, www.priv.gc.ca/en/privacy-topics/privacy-laws-in-canada/the-personal-information-protection-and-electronic-documents-act-pipeda/.

[3] "What Is Dementia?" *Alzheimer's Disease and Dementia*, 2019, www.alz.org/alzheimers-dementia/what-is-dementia.

12. Appendices (1 %)

Such as algorithms, source code or links to Github repositories, diagrams, etc.

Github Link:

13. Contribution Matrix

The contribution matrix provides details on how each member has contributed to the content of the report both in writing and material. For example, the list of tasks and contributors are shown in Table 13.1.

Table 13.1: Contribution matrix

Tasks	People			
	Mohammed Hameeduddin	Abdur-rahman Ansari	Mingwei Zhang	Dhanushga Lionel
Task 1	25%	25%	25%	25%
Task 2	30%			70%
Task 3				
Task 4				
Task 5				
Task 6	15%	15%	70%	
Task 7		30%		70%
Task 8			100%	
Task 9			50%	50%
Task 10	25%	25%		50%
Task 11		25%	25%	50%
Task 12				