



Bilkent University

Department of Computer Engineering

Senior Design Project

craftual: a 3D model viewer and an asset management, presentation-based cloud platform

High Level Design Report

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27 December 2020

This report is submitted to the Department of Computer Engineering of Bilkent University in partial fulfillment of the requirements of the Senior Design Project course CS491/2.

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1. Introduction

Presentations are an important part of work life that help people explain ideas, concepts and topics either for educational purposes or for other work related purposes. A survey conveyed with people working on different areas showed that 92% of the employees believed that presentation skills are critical for success at work. Yet 75% of adults are estimated to be affected by public speaking hindering their ability to be successful.[1] Aiming to help people affected by this condition we thought of ways to reduce their fear by boosting their confidence. The best tool to do this is to help people create a more unique and well-designed presentation. Research showed that 91% of people felt more confident during presentations when they were presenting with a well-designed slide deck.[2] The traditional presentation is made using Microsoft Powerpoint and consists of text and usually stock images. However, an estimated 79% of employees find these presentations boring and they claim that they often lose their concentration after the first 10 min. A novel approach that would increase the interest of people on these presentations is using 3D presentations in combination with AR technology. This technology could be used on the creative stage as well as the presentation of the final product. The interactive interface would allow the user to observe how small changes would affect the overall design of the product since all the components are in the appropriate ratios. Being able to easily see how minor or major changes influence the final product is a huge benefit regarding efficiency as it will prevent costly adjustments that were not foreseen. Easy remodelling and editing makes more accurate designs which means less cost and time invested. The 3D product presentation would offer a much more vivid depiction of the product that a 2D presentation could ever depict.

1.1 Purpose of the system

The purpose of our system has two aspects. The practical aspect which tries to provide the best technical efficiency for the program, and the theoretical aspect which will be the real life comforts our software offers to users in their respective professional discipline.

Firstly, let us consider the practical aspect. The purpose of the system in this regard is to give the best user experience possible. In order to achieve this, we upkeep all our design goals such as efficiency and security. The technical purpose of the system is that it operates smoothly without any errors or long response times. The system should support any number of users without a decrease in efficiency. Furthermore, the security of any personal information or intellectual property of users is of the utmost importance.

When it comes to the theoretical aspect, our objective is to bring together people from different areas of expertise and subject them to new ideas and products. Our system also aims to help

people with their presentation skills by offering a new, dynamic and more engaging alternative to PowerPoint presentations. Most people believe that simple PowerPoint presentations are tedious and do not catch the audience's attention well. Moreover, many working adults are victims to certain levels of public speaking fears. Research shows that having a unique and interesting presentation gives people more confidence which often results in better presentation results.

1.2 Design goals

1.2.1 Usability

- The application will be targeted to designers and general users alike so the application should be simple and easy to use. After a short tutorial every user should be able to use the full functionalities of our application.
- Craftual will be available for usage on the web and mobile version. The web app will be supported by the main browsers including Chrome, Firefox, Edge and Safari. The mobile application will be available on the App Store and Google Play.
- User can choose to cache their 3D models and presentations to their device so they can access it while offline as well.

1.2.2 Reliability

- Craftual shall reside in Cloud-Based systems for high availability
- User data and content will be stored in the Cloud-Based System to ensure data availability and consistency.
- Users will receive messages in real time.
- The payment made via our application should be safe and reach their target destination.

1.2.3 Security

1.2.3.1 User Authentication

- craftual shall store passwords of the user with a combination of hashing and salting.
- craftual shall provide 2-factor authentication.

1.2.3.2 Sanitizing and Validating User Input

- craftual shall sanitize the input from interactive form fields to prevent database injections and cross-site scripting (XSS) attacks.

1.2.3.3 Data Exposure

- craftual makes sure that any model that is shared privately, cannot be seen and modified by other users.
- craftual shall have an SSL Certificate (HTTPS) to ensure the protection of user-data.

1.2.4 Performance

- craftual shall provide an efficient loader for 3D contents.
- craftual shall provide responsive and low latency user-interface.

- craftual shall provide high performance rendering of the 3D models to offer real-time inspection to the user.

1.2.5 Scalability

- craftual shall handle multiple simultaneous uploads and downloads from multiple users by efficiently utilizing the network I/O.
- Even though the number of users logging into the system is excessive, the system takes care of these requests without getting into a bottleneck.

1.3 Definitions, acronyms, and abbreviations

AR Augmented Reality

VR Virtual Reality

GUI Graphical User Interface

UML Unified Modelling Language

XSS Cross Site Scripting

DBM Database Management

API Application Programming Interface

I/O Input/Output

HTTP Hypertext Transfer Protocol

DAC Discretionary Access Control

MAC Mandatory Access Control

1.4 Overview

The aim of craftual is providing an environment in which the users can upload their models, publish their models, create presentations and give feedback and comment on other users' models. With craftual, users can visualize and inspect 3D models on mobile devices with AR and can create presentations compatible with AR.

The ability to discover new models by tags or categories and to download published models for private usage, as well as having an option to share those models is what makes craftual an interactive virtual tool, from engineers and architects to artists.

Collaboration we offer to our users will be most useful when having a different perspective is invaluable. Moreover, users can potentially collaborate with each other in circumstances such as a freelancer 3D modeling artist looking for a job and a recruiter discovering a talent using craftual.

2. Current software architecture

There are a few systems such as Jigspace and Brio that offer services similar to our proposed solution.[3,4] The main issue with these systems is that the users have to create all the 3D models themselves which could be time consuming and introduce unnecessary work. We intend to simplify the user experience by also introducing a marketplace where users can share their designs. Using this feature we expect to create an environment where everyone will be able to have access to various models and integrate them to their own projects.

3. Proposed software architecture

3.1 Overview

In this section we will explain the subsystem decomposition of our project in terms of the subsystem responsibilities, dependencies among subsystem, subsystem mapping to hardware and major policy decisions such as control flow, access control and data storage. We will start by introducing our proposed subsystem decomposition and explain why we are choosing this particular architecture. Next we will describe the hardware and software mapping. In this section we will explain the hardware devices required to access our product and how that hardware device communicates with the software side of our project. Next we will discuss our proposed solution for the persistent data management. Here we will also consider the pros and cons of our proposed database solutions and explain why we made this choice. In the following section we will discuss access control and security where we will go in detail about the security concerns of our product and what steps we are going to follow to shield our app from such vulnerabilities. Lastly, we focus on the bigger picture and discuss how the overall system is controlled on a global scale.

3.2 Subsystem decomposition

While considering possible architectural styles for our subsystem decomposition, we focused on a solution that would help modularise our system in such a way that we could minimize coupling and

maximize cohesion. To achieve our goals we decided that the Client-Server architecture would be most suitable option for our project. The client side of our project is responsible for interacting with the users while the server side of our application maintains the data and provides services to the client. The client and the server communicate via HTTP requests.

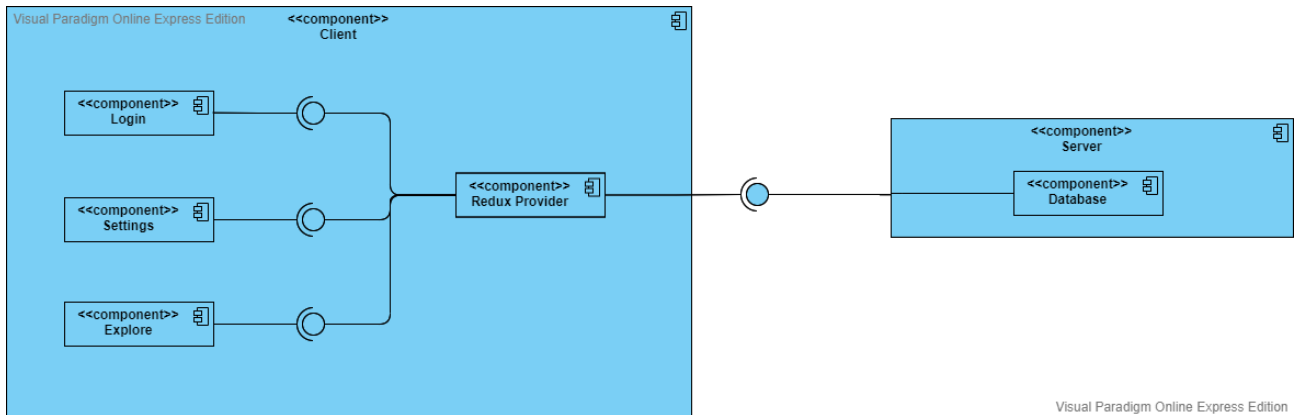


Figure 1. Overall Architecture

3.3 Hardware/software mapping

Craftual is an app that can run on any Android smartphones/tablets or with the browser. That means there are two types of clients. First one is a mobile client that runs on an Android operating system and the second one is a browser client which will run on Windows operating system. So, the craftual app that runs with any client must be compatible with available Android versions and any possible browser. The hardware of the client side will be the hardware of each user using our application. Our app will use the resources of each user like memory, camera, microphone and so forth for rendering their models and making a presentation with them. We will use the user's device memory to save their presentation.

Backend service of our application will be implemented in Java programming language to respond to any HTTP request from the client-side. All clients will use the HTTP procedure to communicate with the server. We will use NoSql for persistent data management. We will keep the user's information like credentials, models etc to access from our backend. We will use Amazon Web Service for our backend service.

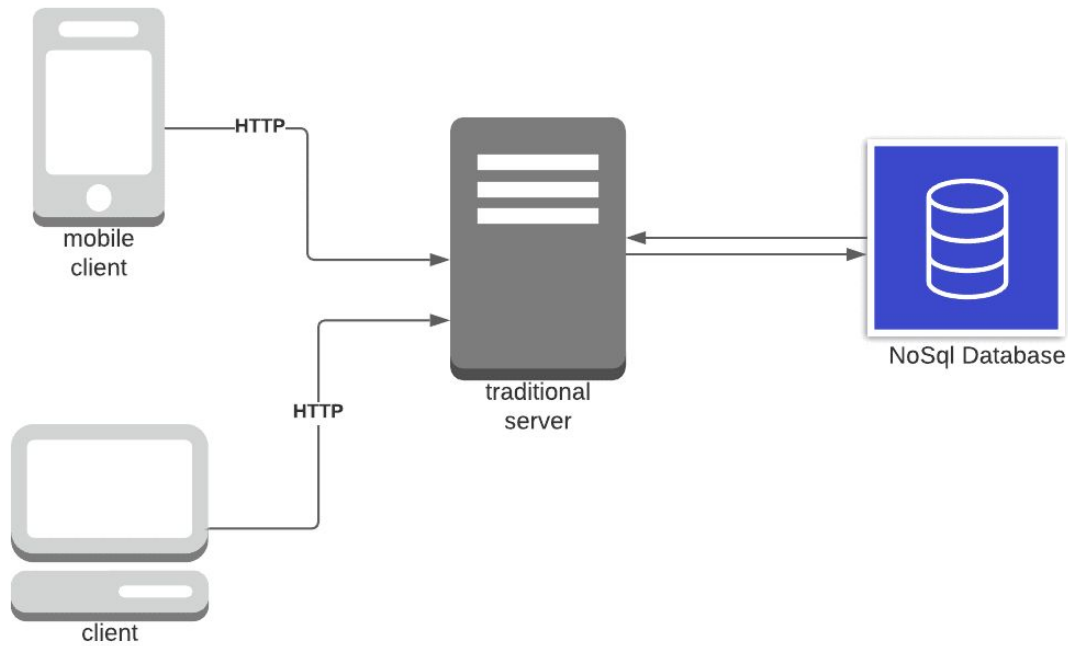


Figure 2. Communication with the Server

3.4 Persistent data management

Data access and storage is the most important issue on our system because most of the functionalities come from accessing and computing the data like downloading/uploading/rendering models so it has to be as fast as possible. If accessing the data will slow, our system will be as slow as the data access. We will only keep models of users in our system if the users give permission to do that.

We will also need tables in our database to store user's login information like username, password, logs etc. Any data/model that is shared with our system will be protected from other user's unless they make it public for other users. Security of the data is our responsibility so that data security will be as important as data access speed. There are some best practices that we will follow for database security and those are as follows [5]

- Encryption of the data
- Managing database access tightly
- Monitor database activities
- Database firewalls

3.5 Access control and security

craftual's creative platform allows users to share, browse and download 3D assets. Assets which are 3D models or scenes created with any 3D modeller that produces a file that's compatible with our requirements, can also be uploaded to craftual. Uploaded and publicly visible assets are licensed under the CC BY [6] license, which means developers can use them in their apps as long as the creator is given credit.

craftual's access control is a combination of Discretionary Access Control (DAC) "as a means of restricting access to objects based on the identity of subjects and/or groups to which they belong. The controls are discretionary in the sense that a subject with a certain access permission is capable of passing that permission on to any other subject (unless restrained by mandatory access control)" defined by the Trusted Computer System Evaluation Criteria [7] and Mandatory Access Control (MAC).

In our DAC model, users are the owners of the data and act as their administrators. Every asset has an owner that controls the permissions to access the object. Users have the ability to make policy decisions similar to Unix file mode in the sense of read permissions.

While MAC imposes the assets that can only be changed, modified by the user (owner) itself, the owner has the ability to change the asset's read permissions either as private or public.

	Asset A	Asset B
Alice	Read, Write	Read
Bob	-	Read, Write

Figure 3. Access Control Matrix

From the previous figure, Alice is the owner of Asset A and has the permission to read (view) Asset B. Bob is the owner of Asset B and doesn't have the permission to read Asset A since the owner (Alice) changed access policy to private.

3.6 Global software control

In the following section, we discuss how the entirety of the system is controlled on a global scale. We illustrate the interactions between the subsystems, how the initialization takes place and some concurrency issues.

In order to give a clear and understandable abstraction, we divide the project into two main parts as Client and Server. We do this because the general structure of the software works by sending

requests to the server and delivering the appropriate responses back to clients. This process follows the below procedures to achieve completion.

3.6.1 Request Part

Users have a variety of functions they can use such as creating a presentation, downloading a model, etc. Any of these functionalities creates a request to the server. For instance, after a user is done browsing a model and wants to download, a request is made on the client side to send the model to the client.

3.6.2 Processing Part

Upon arrival of a request to the server, the input is put through the required functionalities depending on what type of request is made. The needed processing could be an insertion or retrieval of the input item from the database. Usually the processing phase is the most cost and the resource heavy part. However, our software does little work on the given inputs and its main function is storing them. This leads us to believe there will not be a very high response time but the possibility of overloading the servers due to an immense number of requests always exists. To combat this, we will use as many servers as we can without breaking the cost constraints and try to implement efficient process scheduling and load balancing algorithms.

3.6.3 Response Part

In the response part, the output after the processing, if any exists, is sent back to the respective client that triggered the request. This part is essentially a display of the output or the acknowledgement that the input has been processed successfully.

3.7 Boundary conditions

Our software has three potential boundary conditions. These can occur during the start of the application, end of the application, and during use of application. Each of these possibilities are considered in the following sections.

3.7.1 Initialization & Log in

To use the software, the user must have the application installed on their device. To log in, the user needs a registered account or they can create one when first using the application. To authenticate an account, the user must have a stable internet connection and to use some of the functionalities of the application a working camera on the device is required.

3.7.2 Termination

There are no significant boundaries upon termination of the application. Users can choose to create presentations but not upload it, in which case they will be stored in the device's local disk. However, if a user exits during the creation of a presentation, any unsaved changes will be lost when reopening the app.

3.7.3 Run-time

One of the potential run-time failures is the loss of internet connection when browsing or uploading products. Should this happen, the application will have to wait until the connection is restored to resume the process and the user will be notified with an error message.

Another potential problem is bugs in the code or problems with the server. In which case, the user will be notified with an error message that there is a problem and another message when the problem is resolved. Database problems are usually not complex and result from poor database design such as no normalization or poor primary key choice. There are few occasions that using database servers with virtual environments lead to crashes. However, these are very rare events and not caused by nor can be fixed by the software. In cases of such events or simply time-outs from slow servers will display an error message to the user.

The third case of possible failure is when trying to upload models or presentations of unsupported types. There are visual reminders present in upload pages that specify which types are supported. However, should this occur, the upload is unsuccessful and the user is sent a message that the type is not supported.

Final type of failure happens when the user tries to save a presentation with not enough space left on the device. In this case the user will be alerted via message and will not be able to save the presentation until enough space is cleared. Users can do this without having to close the application or lose the presentation.

4. Subsystem services

4.1 Client

The client subsystem of our project is the part of the application that interacts directly with the user. This subsystem is composed of Login, Explore and Settings components which interact with the user and a Redux Provider component which is used to manage the data requests of the application from a central location.

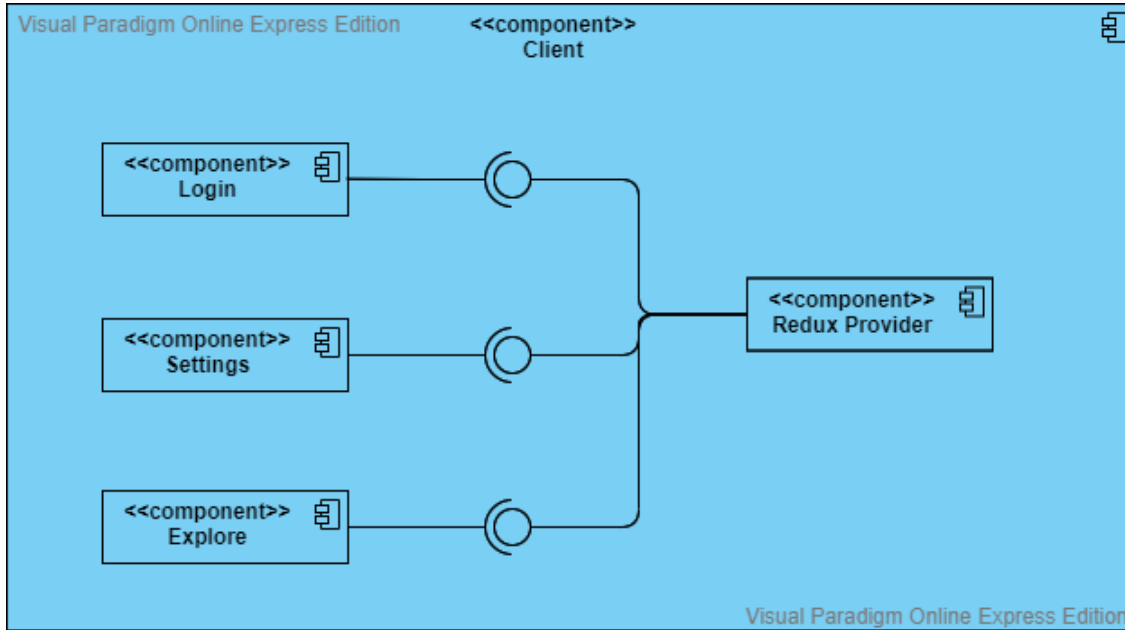


Figure 4. Client Component

4.1.1 Login Component

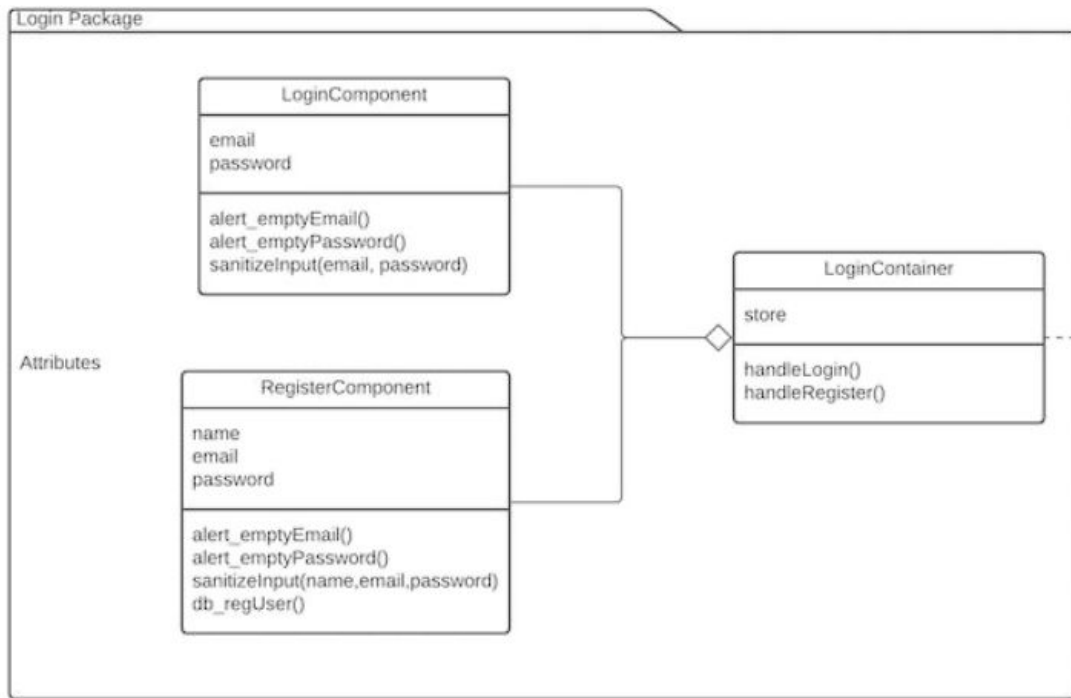


Figure 5. Login Package

Component contains user email and password attributes and is responsible for handling user login and registration requests with the server. Performs the user authentication and registration through Redux.

4.1.2 Explore

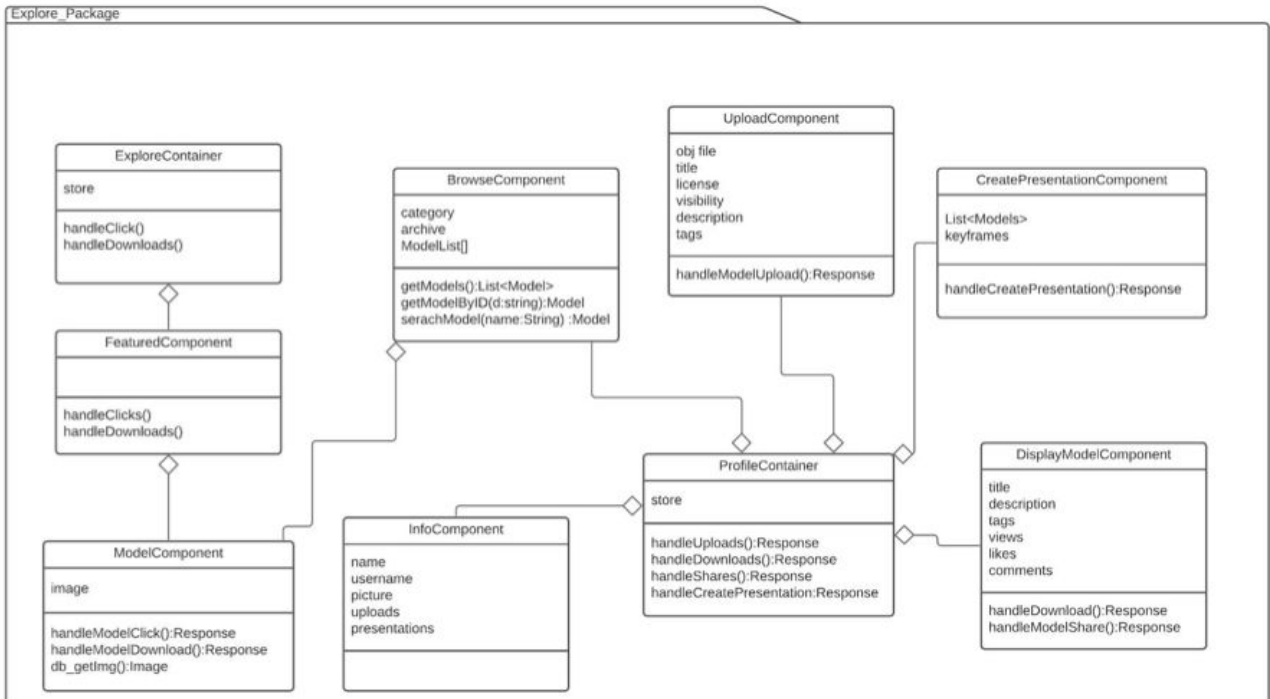


Figure 6. Explore Package

Explore package combines profiles and items in a single high level set. Has the sub-components UploadComponent, which stores the path for the asset, licence, title, visibility, item description and tags as attributes.

ProfileContainer links the Model with the profiles with respective attributes in addition to the UploadComponent title, views, likes and comments.

4.1.3 Settings

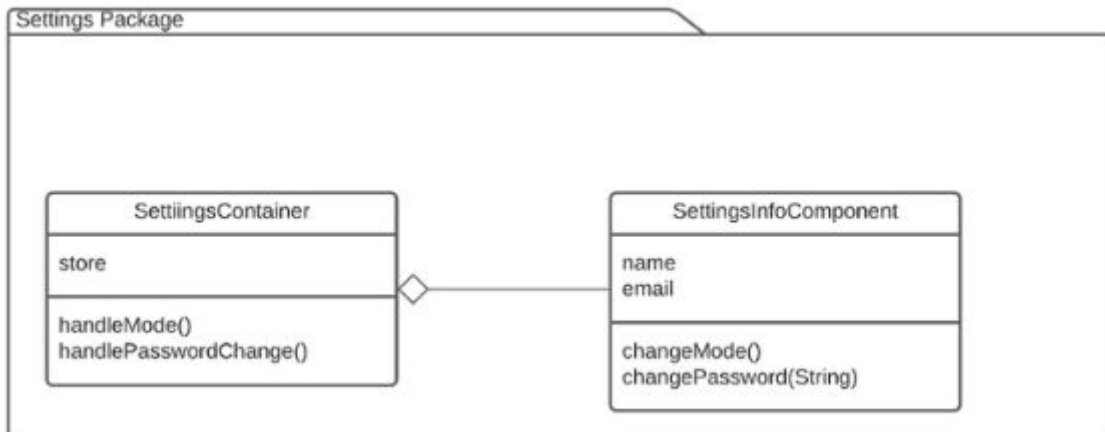


Figure 7. Settings Package

Settings Component handles user's profile changes such as password or credential changes, also responsible for change of the interface between light or dark mode.

4.1.4 Redux Component

The Redux Component that lies on the client side of the application and is responsible with managing the data flow. This component is used to abstract the data from the UI so we can achieve a more modularised code which is also easier to debug. Whenever the user requests some data, redux is responsible for providing that data. Redux has direct access to the server side of our application so that it can query the necessary information at any given moment.

4.2 Server

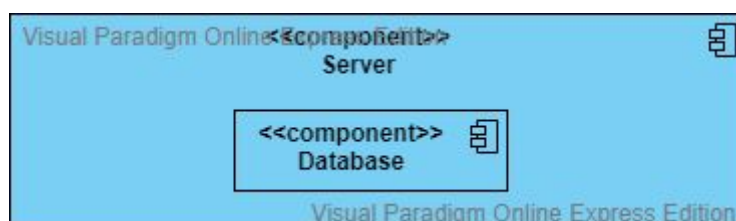


Figure 8. Server Component

Server is where all the user requests are handled. The working principle of the server is in request/response procedure. For example, if a user wants to upload a model into our system, he/she sends a request to the server from the client and that request is handled by the server itself.

Authentication and authorization is handled in the controller in the server by checking each of the requests to have access token and scope or not. Controller intercept the request, after checking the access token it forwards the request to the corresponding service.

Server handles all the CRUD operations which come from the requests via accessing the database. There is no validation here for requests because the controller had already done it before coming to the service. This subsystem stands for managing local storage in which uploading, downloading or deleting models via requests. NoSql is used for our database. All the logs of the databases are recorded in the server with timestamptz, corresponding user credentials, and metadata of the file.

5. Consideration of Various Factors in Engineering

Design

The potential factors that are considered during the engineering design process, the decisions made around these factors and how these decisions may affect user experience as well as overall performance and social impact of the project will be discussed in this section. In particular, the concerns about public health, economic factors, social & cultural factors and lastly environmental factors are argued in their respective sections.

5.1 Public Health

While there are not any major public health concerns regarding craftual, as compared to other augmented reality applications on the market, it requires minimal mobility on the user part, certain aspects of the product which are natural to augmented reality applications may lead to foreseeable indirect health concerns, namely psychological effects of using an interactive online social platform or the possibility of the visuals from the devices causing epilepsy seizures. However, although it can be considered as a social media platform, craftual will be mainly about products and work & education related artifacts, and not the users themselves. This will limit any potential abuse between users and encourage feedback on the products.

5.2 Economic Factors

Craftual brings together many different practises that make use of 3D modelling such as marketing, architecture, engineering and even entertainment. Its main purpose is to provide a platform; on

which the users can advertise, publish and get feedback on their products. While being free to download, there is little to no doubt that freelance worker users of craftual may find work related opportunities in their line of work. Moreover, employers and recruiters may find potential employees and as a result, all users of craftual may benefit from its indirect financial opportunities.

5.3 Social and Cultural Factors

As it is oblivious to nationality, age, gender or social status of the users, craftual is not concerned to affect or be affected by social and cultural factors. In a more general assessment of the matter, we might say that privacy of the user’s credentials and sensitive information is an issue. However, as is the case with all applications that record personal information. We will follow the general regulations to assure safety of any sensitive information.

5.4 Environmental Factors

When designing an app like Craftual, the environment plays a big role in how it will perform since it uses augmented reality. All aspects of the background environment must be taken into consideration since the models will differ in color, size, place, and shape and it will greatly affect the UI and, by extension, the quality of user experience. Interfaces of augmented reality applications aren’t necessarily tied to concrete screens, they are interactive. Therefore it is important to define what kind of objects the user will interact with and on what kind of frames. Our application does not have tight environment constraints, however, it does require a flat visible surface to avoid problems.

The table below provides levels of significance for the aforementioned factors that range from 1-10. The levels are based on the likelihood of the concerns happening and their impact on the applications performance or the user’s experience. Certain factors like Public Safety are not included as our project is in no way connected to public safety and therefore its level is virtually zero.

	Level	Effect
Public Health	3	May lead to psychological or physical problems

Economics	7	Bigger customer profiles, increased income
Social & Cultural	5	Information privacy
Environmental	8	Performance of the app

6. Teamwork Details

In order to ensure every member is involved and taking part in every aspect of the project, we created a project plan consisting of work packages and assigned a leader to every work package. This way, we ensured that the leader role is circulating between team members. Moreover, every team member is involved in every work package. This way, we guaranteed collaboration between team members and contribution of each team member in all parts of the project.

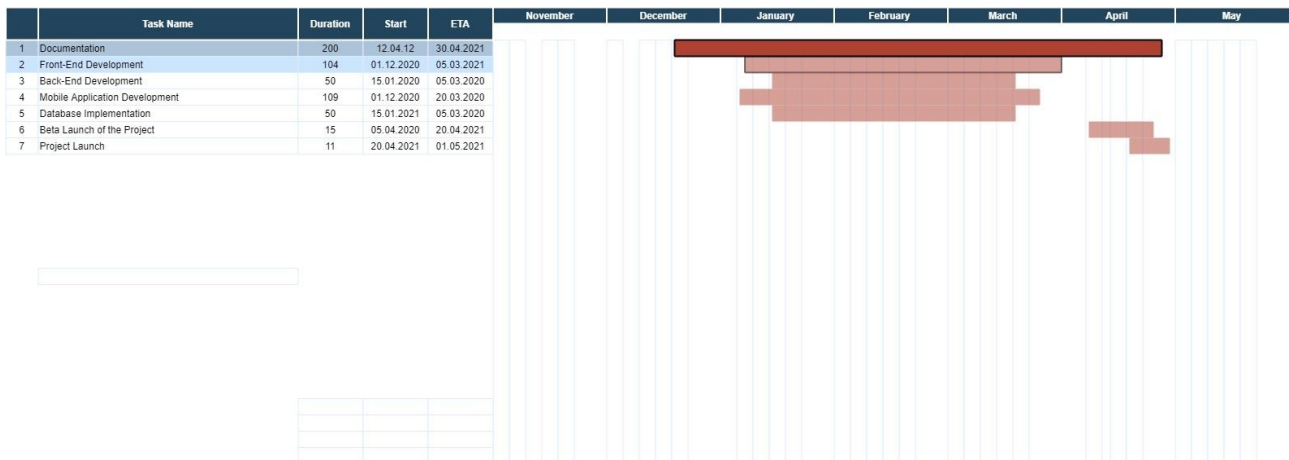


Figure 99. Project Plan

6.1 Contributing and functioning effectively on the team

To make certain that each team member is contributing and functioning effectively on the team, we assigned each team member to all work packages. This, as well as ensuring collaboration and teamwork, helps to get a better understanding of every aspect of the project and acquire new knowledge and skills for each team member. Assigning each team member to a work package related to their past experience might provide a smoother implementation process. However, it has a downside of not getting experience on an unfamiliar topic. Another advantage of distributing the workload this way is, it is closer to a fair and homogeneous distribution. The distribution of work packages is as follows:

Table 1. The Distribution of Work Packages

WP	Work Package Title	Leader	Members Involved
WP 1	Documentation	Endri Suknaj	All Members
WP 2	Front-End Development	Çağrı Orhan	All Members
WP 3	Back-End Development	Deniz Doğanay	All Members
WP 4	Mobile Application Development	Doruk Altan	All Members
WP 5	Database Implementation	Sencer Umut Balkan	Çağrı Orhan, Deniz Doğanay, Doruk Altan
WP 6	Beta Launch of Project	Endri Suknaj	All Members
WP 7	Project Launch	Sencer Umut Balkan	All Members

6.2 Helping creating a collaborative and inclusive environment

In order to ensure every member is involved and taking part in every aspect of the project, we have decided to use tools that can monitor our progress as a team, as well as individual progress of each team member. Monitoring progress as a team is the key to create and establish a collaborative and inclusive environment in terms of verification and confirmation. Therefore, tracking progress from these tools is the way we chose. Such tools are as follows:

6.2.1 Github

Using Github, we will be able to monitor the contribution of each team member and the overall progress of the project. We will divide work to be done, which is necessary for proper teamwork and relevant workload distribution, with features provided by Github.

6.2.2 Discord

We have created a Discord server mainly in order to keep track of communication between team members, as well as highlight tasks and deadlines. We will also be able to carry out group

meetings and post completed tasks in the form of reports to our Discord server, which helps keeping track of progress as well.

6.2.3 Zoom

Zoom will be used in place of real-life meetings. With features such as screen sharing and video conferencing, we predict that using Zoom will not put us at a disadvantage rather than gathering in person. We will schedule meetings at times when every team member is available, in order to have every team member's idea about the topic that will be discussed in that particular meeting. Zoom and Discord may be used interchangeably for meeting purposes.

6.3 Taking lead role and sharing leadership on the team

As discussed at the beginning of this section, we planned to circulate leadership between work packages. This means acquiring a significant skill for each team member which will allow every team member in any potential similar duty in their professional life. However, being a leader in a work package does not mean that most of the work will be done by that specific team member, rather, it involves managing other team members' progression as well as making the final decision of whether the actual work done related to that specific work package is done professionally and looking good in every aspect. Additionally, circulating leadership ensures a better understanding and contribution to all parts of the project.

7. References

- [1] Visual Learning Center by Visme. 2020. *24 Presentation Statistics You Should Know In 2020*. [online] Available at: <<https://visme.co/blog/presentation-statistics/>> [Accessed 27 December 2020].
- [2] Presentationpanda.com. 2020. *Presentation Statistics (Based On Real-World Survey Data!)*. [online] Available at: <<https://presentationpanda.com/blog/new-presentation-statistics/>> [Accessed 27 December 2020].
- [3] Inc, J., 2020. *Jig Workshop Pro - 3D Product Demos Made Easy*. [online] Workshop.jig.space. Available at: <<https://workshop.jig.space/pro>> [Accessed 21 November 2020].
- [4] BRIOVR. 2020. *3D Visualization Software For AR & VR - Create, Publish, Share | BRIO*. [online] Available at: <<https://experience.briovr.com/>> [Accessed 21 November 2020].
- [5] "7 Database Security Best Practices: eSecurity Planet," *eSecurityPlanet*, 18-Nov-2020. [Online]. Available: <https://www.esecurityplanet.com/networks/database-security-best-practices/>. [Accessed: 27-Dec-2020].
- [6] "Creative Commons Attribution 3.0," *Creative Commons Legal Code*. [Online]. Available: <https://creativecommons.org/licenses/by/3.0/legalcode>. [Accessed: 27-Dec-2020].
- [7] *DEPARTMENT OF DEFENSE TRUSTED COMPUTER SYSTEM EVALUATION CRITERIA*, Dec-1985. [Online]. Available: <https://web.archive.org/web/20060527214348/http://www.radium.ncsc.mil/tpep/library/rainbow/5200.28-STD.html>. [Accessed: 27-Dec-2020].