Creating a Virtual Reality Meditation Visualisation System

Requirement Specification

Simon Zaragoza-Dorwald, Rosie Bartlett, Lavish Bhojani, Dravin Gupta, Joseph Dunne, Callum Gray

November 16, 2022

Contents

1 Introduction

1.1 Overview and Justification

This document provides the requirement specifications for our virtual reality (VR) meditation application, referred to henceforth as ‘the product’; the specific software for the product shall be referred to as ‘the software’. This document provides an introduction (section 1) to the project, covering the justification (section 1.1), scope (section 1.2), and systems (section 1.3); the requirements for the system (section 2), both functional (section 2.1) and non-functional (section 2.2), and potential risks and issues (section 2.3); the development of the project (section 3) in terms of the approach (section 3.1) and schedule (section 3.2).

This project is for Professor Alexandra Cristea who shall henceforth be referred to as ’the client’. The client has given us the project of developing a VR meditation application with the possible use as a basis for research into the topic. This project aims to help those who have not done any, or have done very little, meditation before by giving them an immersive VR world to aid concentration and relaxation.

1.2 Project Scope

This project is intended for those who have never done any, or done very little, meditation before. It is aimed primarily at adults. The app is intended to help with mindfulness meditation (MM) practice through the use of gamification concepts and VR. The primary objectives are as follows:

- Personalisation over customisation
  The client would prefer for the project to personalise, that is automatic adjustments to suit the user, itself rather than have the user customise the project, that is allowing the user to alter the environment
- Stability
  The client would prefer fewer stable features over more less-stable features
- Modularity
  The client would prefer the software to be modular to allow for ease of reuse in future projects

The client would also like the potential to use the project later on in a research context. This is not a primary consideration of ours, but we will use this to guide our development. To ensure that our project can be as seamlessly used in this context with little impact on the project itself, we will make reference to relevant literature where necessary to ensure our implementations of MM is as concurrent with current literature as we can make it[1].

For some examples of literature we will likely make reference of, see [2, 5, 7]. We will also make significant reference to [4] as a good example of research into a similar topic.

1.3 System Description

The system will be a VR app intended for meditation with aspects of gamification[6] using the Meta Quest[2]. The app is intended to aid with visualisation based meditation and to accelerate the progression through meditation training.

The primary section of the app will be set in an environment designed to have as little distraction as possible whilst still allowing the app to be engaging. At present, we intend for the environment to be relatively featureless, with some objects orbiting the user. The objects will themselves have particles around them to obfuscate any highly contrasting areas. Each session will be approximately 10 to 20 minutes in length and various metrics will be measured throughout such as heart rate, EEG data, and eye tracking. This will be analysed and stored externally in accordance with the GDPR.

Evaluation metrics will be applied to the raw data, the results of which will be used to compare sessions and measure improvement. These metrics will be user-specific and will require user-specific baseline data, as well as general data. To gather this baseline data, a short (at most 5 minutes) baseline session will be required before the user can complete any meditation.

The data metrics will be constructed to account for global limits and will be personalised, via user-specific data, to ensure that any change can be measured relatively to the user and not to some global standard. With this we aim to ensure that all users can see a clear progression from session to session.

Each user will have an associated account that will communicate with the server. This account will contain the user's name and personalisation data. The user will be able to access a history of sessions via a request to the server.

The server itself will be run by a Python script that can be run on any computer. For the purpose of product demonstration, we will ensure the same computer runs both the server and Quest app in lieu of a server with a static IP. The server will store user account data,

[1]The authors can find little research on MM with VR implementations. There is a significant amounts of research into VR applications and MM separately which we will use to guide our development

[2]Previously Oculus Quest

raw session data, and session metric results. Data will be stored in a XML format, with each user having a folder under their username, with sessions and user data within that folder. Current, incomplete, XML DTD are given in appendix A.

1.3.1 Current systems

There exists several current systems for integrating VR into meditation. We will briefly discuss two of these such systems here.

Lan et al. [4] demonstrated a feasible study for multimodal feedback meditation in VR. They used g-tummo meditation which has some well researched benefits [3] but is a fairly advanced technique. As such the multimodal feedback system allows less experienced meditators to feel a more immediate feedback from meditation and thus attempt to help motivate people to continue meditation. This research showed that the multimodal feedback correlated with a decrease in breathing rate and helped maintain user attention, measured via tiredness.

Hølledig et al. [1] demonstrated a VR based meditation environment also using biofeedback. Their environment was a generated forest environment with different amounts of fog depending on real-time evaluation of the user's meditative state. Whilst they failed to show any meaningful benefits, they do note that the use of biofeedback has potential to be useful. The authors also note of significant issue with the Myndplay headband that resulted in having to redesign their tests.

2 Solution Requirements

2.1 Functional Requirements

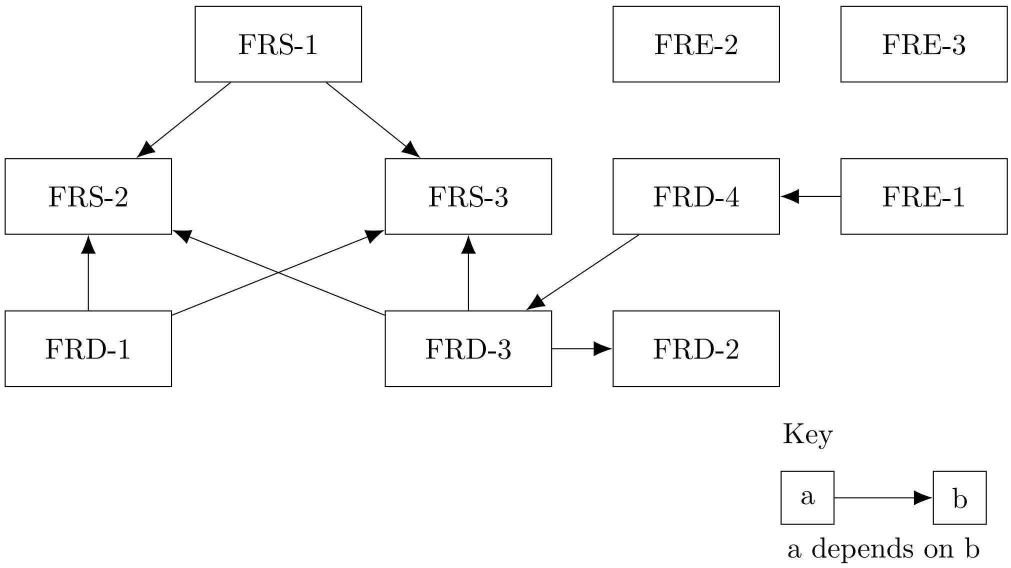

Figure 2.1: Functional dependency graph

2.1.1 Sensor Requirements

ID - Name	**FRS-1 - Baseline Readings**
Description	Baseline readings should be taken for each new user of the software. This should occur over 90 seconds where the user remains seated without the VR headset on
MuShCo - Priority	Medium - Should have Baseline values could be inferred from averages i.e. average heart rate for someone the same age, however, this wouldn't be ideal
Dependencies	FRS-2, FRS-3
Expected Results	Obtain an average value for the heart rate, concentration and meditation values of the user prior to meditating.
Exception handling	If calibration fails then check the positioning of the sensors on the user and reposition if necessary. If that fails try again after resetting and restarting the failing sensor

ID - Name	**FRS-2 - Heart Rate Monitor Connectivity**

Description	The heart rate monitor should return readings at regular intervals through a Bluetooth connection
MuShCo - Priority	High - Must have For the application to be adaptive, it needs to have a constant data stream of heart rate data
Dependencies	None
Expected Results	Obtain a constant stream of data detailing the heart rate of the user at specific times
Exception handling	If calibration fails then check the positioning of the sensor on the user and reposition if necessary. If that fails try again after resetting and restarting the heart rate monitor

ID - Name	**FRS-3 - EEG Connectivity**
Description	The EEG should return readings at regular intervals through a Bluetooth connection
MuShCo - Priority	High - Must have For the application to be adaptive, it needs to have a constant data stream of values from the EEG
Dependencies	None
Expected Results	Obtain a constant stream of data detailing the concentration and meditation score of the user at specific times
Exception handling	If calibration fails then check the positioning of the sensor on the user and reposition if necessary. If that fails try again after resetting and restarting the EEG

2.1.2 Data Collection Requirements

ID - Name	**FRD-1 - Storing Sensor Data**
Description	EEG and Heart Rate readings should be stored with timestamps throughout the session

MuShCo - Priority	High - Must have As emphasised by our client, making sure to generate data that can be studied is perhaps the most important requirement of our system
Dependencies	FRS2, FRS3
Expected Results	Obtain an XML file for each session with EEG and heart rate data fields included
Exception handling	Identify whether the exception occurs because of the connectivity of the sensors or the code for producing data files. If it is the former case, then refer to exception handling for FRS2 and FRS3. If it is the latter case then not much can be done apart from providing a form for feedback as this would be a bug in the code

ID - Name	**FRD-2 - Storing User Behaviour**
Description	Behaviour about how the user interacts with the virtual environment should be stored with timestamps. This includes what their attention is focussed on and their movement
MuShCo - Priority	High - Should have Although generating data that can be studied is very important for our application, data that is collected from the sensors is of greater importance. Collecting data from how the user interacts with the environment could be difficult and so although we would like this to be done, it is not a must have requirement
Dependencies	None
Expected Results	Obtain an XML file for each session with user gaze tracking data
Exception handling	An exception occurring would mean a failure of the code. Not much can be done apart from providing a form for feedback as this would be a bug in the code

ID - Name	**FRD-3 - Performance of meditation is measured and displayed at the end of a session**

Description	The user's performance throughout the meditation exercise should be evaluated, and then displayed to them at the end of a session
MuShCo - Priority	Medium - Could have Seeing how you performed after a session gamifies the program and gives the user insight into how well they have performed, but it is not a crucial feature from speaking to the client
Dependencies	FRS2, FRS3, FRD2
Expected Results	A value, calculated from a mixture of variables, including heart rate, meditation value (from the EEG), head movement. This value would indicate how well the user meditated
Exception handling	Two main types of exception could occur for this requirement. If the value is not well computed, i.e the formula used does not accurately indicate how well the user has meditated, a feedback form could be provided where users could share their opinion. The formula could be perhaps reworked in this case. If some code means that the value calculated is not displayed or produces a value outside of the range of 1 to 100 then this is an error in the code. Not much can be done apart from providing a form for feedback

ID - Name	**FRD-4 - Past meditations performance is stored and can be displayed against session number in a graph**
Description	For a particular user, performance from session to session will be stored and can be displayed in a graph for them against the session number

MuShCo - Priority	Medium - Could have Gamifying the meditation would help users become more motivated to continue as they would tangibly be able to see their progress. Despite this, we have called this objective Could Have as such a feature might make the experience more stressful. It is therefore a more experimental requirement, that could be implemented if it was known to aid motivation
Dependencies	FRD-3
Expected Results	A graph, where the y axis is meditation score (from 1 to 100) and the x axis is the session number. Data points will be plotted in this graph with a line connecting them
Exception handling	If the graph is not formatted correctly, or does not display the most recent results, we could have a refresh button to run the code again that produces it

2.1.3 Environmental Requirements

ID - Name	**FRE-1 - Start Menu**
Description	There should be a start menu that allows the user to select whether to do a walkthrough/tutorial, to complete a meditation session or to view their progress
MuShCo - Priority	High - Must have A menu would be necessary to be able to access the various functionality of the software
Dependencies	FRD-4
Expected Results	The user can select one of the three possible options using their hand controllers and then once selected, get access to it
Exception handling	An exception occurring would mean a failure of the code. Not much can be done apart from providing a form for feedback as this would be a bug in the code

ID - Name	FRE-2 - The user should be immersed in a virtual reality environment
Description	The user should be immersed in a virtual world for meditation. At the moment we want to do this in a space themed environment
MuShCo - Priority	High - Must have This is a fundamental requirement for the software so that we can take advantage of VR when compared to more conventional ways of meditating
Dependencies	None
Expected Results	The user's presence should be simulated in a virtual environment. They should be able to look around, move and interact with it
Exception handling	If the user is not properly immersed in the environment we will display a warning message telling them to restart the application and reconfigure their headset

ID - Name	FRE-3 - The user can access a pause menu
Description	During the meditation, if the user is feeling uncomfortable or needs to adjust a or refit a sensor they should be able to easily pause the session
MuShCo - Priority	Medium - Should have The application can always be left through taking the headset off, however it would be
Dependencies	None
Expected Results	The user's presence should be simulated in a virtual environment. They should be able to look around, move and interact with it
Exception handling	If the user is not properly immersed in the environment we will display a warning message telling them to restart the application and reconfigure their headset

2.2 Non-functional Requirements

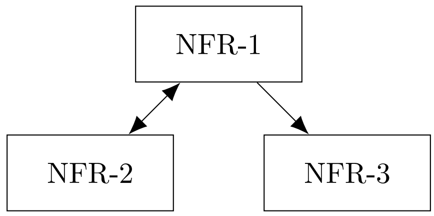

Figure 2.2: Non-functional dependency graph

ID - Name	**NFR-O-1 Modularity**
Description Over multiple lines	Description
Dependencies	No dependencies
Priority	Priority
Metrics	Metrics
Constraints	Constraints

ID - Name	**NFR-S-1 Modularity**
Description	Description Over multiple lines
Dependencies	No dependencies
Priority	Priority
Metrics	Metrics
Constraints	Constraints
Security	Security

2.3 Risks and Issues

2.3.1 Risk Matrix

		Impact		
		Low	Medium	High
Proabability	Unlikely	r1 test	r2	r3
	Possible	r4	r5 test	r6
	Likely	r7	r8	r9 test

3 Project Development

3.1 Development Approach

For our Software Engineering Project, we have decided that an agile approach, specifically Extreme Programming (XP), fits our needs the best. It ensures that we can work on multiple tasks simultaneously and stipulates thorough planning and collaboration, which is inline with our concept

3.1.1 Advantages of Extreme Programming

- Extensive planning

  As detailed in our Project Schedule, our approach has to rely significantly on prior planning and communication. Each piece of code / assessment is meticulously divided into smaller sub-tasks and evaluated based on its length and difficulty. Additionally, the group always confers with the client first to make sure the vision of client till matches the production code.

- Pair programming

  Two people from the group focus solely on the actual development of the software / code and cross check each other's work.

- Simple design

  After meeting whit the client, its has become clear that the data is the primary focus of this project. Personalisation (the collection of data and the subsequent adapting of the meditation) is will be the goal of this project, rather than creating a customizable environment, e.g. prioritizing eye tracking over more colors the user can choose from at the beginning of the meditation. This follows the principle of simple design, since we will focus on raw data collection rather than "bells and whistles".

- Refactoring and continuous integration

  During the primary development phase outlined in section 3.2 we will have to adapt and refactor the code multiple times for adjustment. This could be due to technical limitations and feedback given in the feedback stage in section 3.2. Since the client has requested the code be as clean and understandable as possible due to the fact that it might be used for further research later, we will periodically refactor and simplify the code. This will happen frequently, since we are not experienced with VR or C-sharp.

3.1.2 Disadvantages of other methods

- Waterfall

  The Waterfall method does not offer the flexibility we need to manage this project in the given time frame. Implementing new requirements or coding practices is virtually impossible because everything has to stick to a rigid schedule. Dividing the workload would also not work with this method. In contrast, the XP method allows for more dynamic workflows and and reflects a realistic relationship with the client

- SCRUM

  SCRUM has fixed, predefined roles which we feel are not suited for our project. Since we decide everything together and everyone cross checks everyone, there is no need for a SCRUM Master or a product owner. Additionally, the frequency of meetings and the general time spent on a sprint does not coincide with our project schedule. In contrast, XP does not have a predefined time strucutre and does not have hierarchical structures.

3.2 Project Schedule

Figure 3.1 illustrates our timeline for the duration of this project. The Gantt chart is split into two parts: The actual developing stages of the software/code and the completion of the assessments themselves.

3.2.1 Code

For the software we the phases have familiarisation with the VR-Headsets and C-sharp, the development of the code, feedback from users, testers and the client and minor adjustments in accordance with the provided feedback. Two people will always be working on solely writing the code.

3.2.2 Assessments

Since we have opted for a modular code and work approach, each piece of work we submit is extensively planned and reviewed:

- During the 3-5 days before we start on the assessment we divided up the work and discuss key targets
- Over the next few weeks each person completes their part of the project, while continuously communicating to other members of the group their progress and if they need advice
- When everyone has completed their work, one person reviews every section to help ensure proper spelling, formatting and that every section meets / exceeds expectations
- The revision period does not necessarily only mean revising the actual material. It also means reflecting on the work submitted and figuring out how to improve our collaboration process

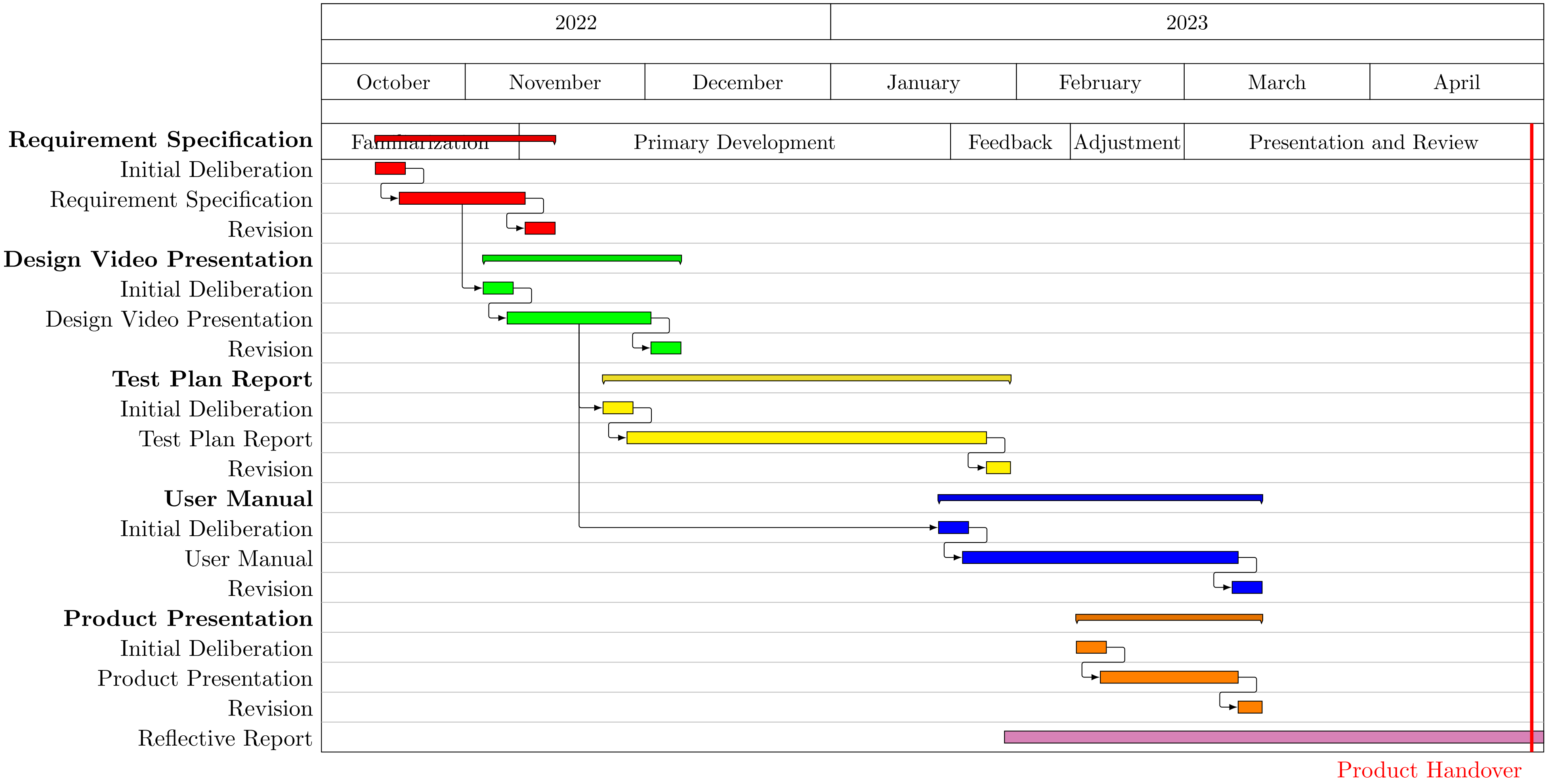

Figure 3.1: Project Schedule Gantt Chart

A XML DTD

This appendix includes the document type definitions (DTD) for the user and session databases. Each DTD is semi-commented to describe the intended purpose of the given tag or attribute. Due to the project not being complete, the DTD are partially incomplete and the complete parts are best estimates. Any unknown section in the DTDs will be indicated by an ellipsis.

```xml
<?xml version="1.0"?>
<!DOCTYPE user [
<!ELEMENT user (name, pers_data)>
<!ATTLIST user id ID #REQUIRED>
<!-- User name string -->
<!ELEMENT name (#PCDATA)>
<!-- User personal data -->
<!ELEMENT pers_data (...)>
]>
```

Listing 1: General DTD for user database

```xml
<?xml version="1.0"?>
<!DOCTYPE session [
<!ELEMENT session (time, HR_data, EEG_data, gaze)>
<!ATTLIST session id ID #REQUIRED>
<!-- Date and time stored as epoch time -->
<!ELEMENT time (#PCDATA)>
<!-- Hear rate data as a list of datapoints -->
<!ELEMENT HR_data ((...)+)>
<!-- EEG data as a list of datapoints -->
<!ELEMENT EEG_data ((...)+)>
<!-- Gaze data as a list of timed datapoints -->
<!ELEMENT gaze ((gaze_element)+)>
<!ELEMENT gaze_element (yaw, pitch)>
<!-- Yaw of the user view -->
<!ELEMENT yaw (#PCDATA)>
<!-- Pitch of the user view -->
<!ELEMENT pitch (#PCDATA)>
<!ATTLIST gaze_element time CDATA #REQUIRED>
]>
```

Listing 2: General DTD for session database

Note that for the child nodes of `HR_data` and `EEG_data` in the session DTD, each will have a time attribute as with the gaze datapoint.

```
<?xml version = "1.0" encoding = "UTF-8" standalone = "no" ?>
<!DOCTYPE session SYSTEM "session.dtd">
<session id="session id">
  <time>1668110361</time>
  <pers_data>
    ...
  </pers_data>
</user>
```

Listing 3: Sample session XML file

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