CS261 Coursework Design Document

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1 Introduction

Deutsche Bank requires a system prototype to support the mentoring process for employees. The principal purpose of this document is to broadly record the process documentation and design choices for said system prototype. For process documentation, this document will detail development methodologies in addition to workflow and project organisation. Design choices include a prototype user interface design and technical diagrams demonstrating user interactions between multiple users and the system. Furthermore, our testing strategy and technical descriptions such as choice of technologies used and system architecture will be covered in depth to illustrate a fuller idea of the final product.

2 Process documentation and planning

2.1 Development methodology

We opted for an agile development methodology based on the Scrum model. The development timeline will be broken down into a large initial planning phase and a series of week-long sprints. We chose to elect our project manager as scrum master, since this role is similar to that of the project manager in organising the team and improving workflow. We will use Trello to create and manage a scrum board, which will allow for easy management of the product backlog. At the start of each sprint, we will meet to discuss the items from the product backlog to be completed in that sprint - this will usually be decided according to the project timeline below, however some small adaptations may need to be made. Each day within the sprint, the team will discuss progress and bring to attention any challenges they are facing. At the end of the sprint, we will carry out a sprint review, and each developer can showcase parts of the system which have been completed. The sprint cycle is completed with a sprint retrospective, where improvements can be made to the development process before the next sprint.

An agile methodology is optimal for a short timeframe as it allows rapid product development with concurrent implementation and testing so we can make effective use of the time available. It also allows for more flexibility if we face unexpected delays during development, which is likely with an inexperienced team. Producing a thorough plan before beginning the agile development process is suitable since deliverable deadlines are fixed, so ensuring work is completed on time is critical. Additionally, contact with the client is limited so requirements are unlikely to change and the project will not deviate much from the initial plan.

2.2 Project organisation and communication

We decided on a flat team hierarchy since we have similar levels of software development experience, self-managed but with well defined responsibilities. To communicate between meetings, we decided to use Discord, as it is already a popular choice within the team and is easy to learn for new users. It offers both text and voice chat as well as a number of features such as GitHub integration, so we are notified via Discord when pull requests are made, for example.

Discord can be used for online meetings however we aim to convene in-person at least twice a week, as this enables us to share ideas much more easily and maintain focus during meetings. At these meetings we can compare progress on the system with our plan, and assign tasks based on documentation or what tasks need doing in order to stay on schedule. We will use Trello to manage the product backlog, and see which tasks are currently in progress, to ensure the project will be completed by the deadline.

2.3 Risk management

Risk	Impact	Likelihood	Severity	Mitigation	Contingency	Residual
Team members unable to work	Smaller team until the member can resume work	2	7	Team members take precautions	Reduce scope and reallocate work across team	2
Task longer than expected	Project delayed until task completed	5	4	Allocate buffer time to allow overrunning tasks	Re-assign team members to load balance	4
Poor code quality	System fails testing or linting procedures	5	4	Code review and automated testing through CI/CD	Re-assign team memebrs to fix pair program	3

Requirements change	Design and existing code must be changed	3	8	Use an agile methodology to facilitate requirements change	Update project plan and proceed with new one	3
Code lost	Code must be rewritten	1	7	Use ‘git‘ as version control, and remote backup to GitHub	Restore code from local or remote backups	1
Problems with dependencies	Component of project fails external library or technology	2	4	Choose technologies and dependencies carefully	Find replacement library or technology	2
Scope creep	Addition of unnecessary features causing growth of project scale	7	4	Include extra features in project timeline, and stick to it	Drop lowest priority features	5

Table 1: The risk register, for our project

2.4 Project schedule

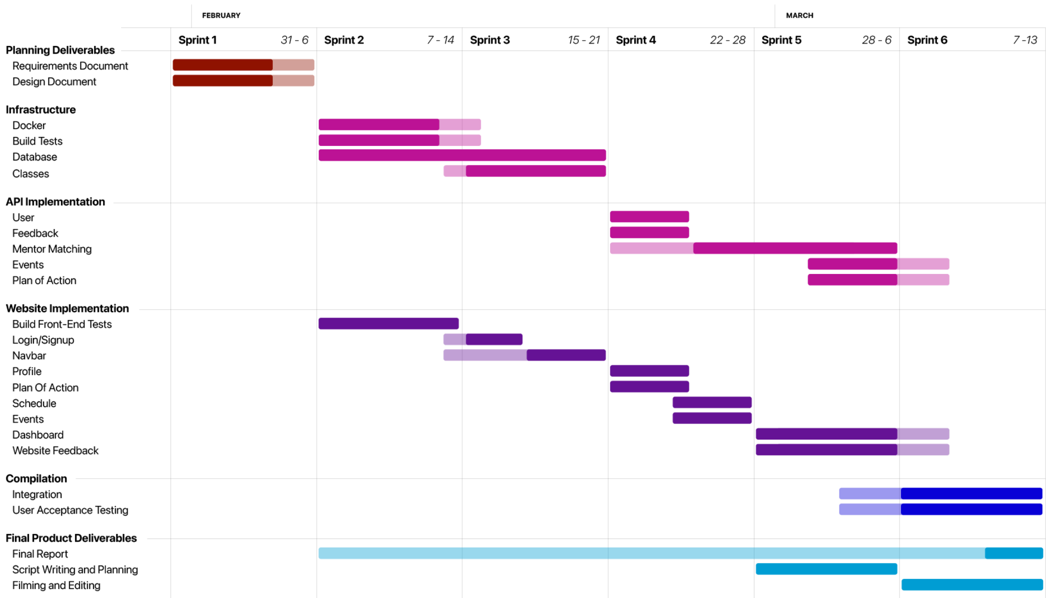


Figure 1: Gantt chart of the project schedule.

The timeline outlines which features of the system will be implemented in each weekly sprint, divided according to the team which is working on them, with final product documentation separated as this is a collaborative effort by the whole team. As we are following a Scrum methodology, task order may be adjusted weekly, ie. in each sprint, so that the project remains on track, so which features are completed in each week will most likely change. It also acts as a reminder that the final report should be completed, when time is available, concurrently with the project itself, so it doesn’t need to be written in its entirety in the few days before submission.

3 Technical description

3.1 Scope

Our system must satisfy a complex specification, so its development must be carefully planned and executed. However, the goal is to create a prototype, not a finished product. This means that some features that would be required in production, which do not fit in the timescale for the prototype, e.g. , or would require integration from external systems, e.g. company calendar applications, should not be implemented. Our requirements analysis fully defines the scope of what we will implement.

3.2 System attributes

It is crucial that the system’s usability is considered. Our goal is to ensure that the website is intuitive to use, has little ambiguity and can ideally be learnt without assistance even by non-technical users. Thorough acceptance testing will be carried out to ensure this is achieved. Along with this, our prototype aims to make our system accessible to people with disabilities, by including features such as enlarging text and higher contrast colours.

Both compatibility and portability are important aspects to consider when designing a system. As the system is a web app, it is inherently compatible since every user will have some access to a device able to run a browser. Furthermore, since websites use standardised languages such as HTML, they are by definition portable across devices running valid browsers. Extreme cases such as legacy browsers will not be prioritised since it is unlikely to be used. The prototype will not include desktop and mobile applications since it would be difficult to make portable across systems, and so is out of the scope of the prototype.

Security is also important to consider, especially due to the legal obligations on processing of user data that grow more stringent over time. It is impossible to have a system which is both functional and perfectly secure, however, the threat surface for any prototype system is very small, so it is sufficient to follow simple best practises, such as account access protection through hashing and salting stored passwords. Data will only be accessed through the REST API, allowing us to ensure only required data is sent, and adds a layer of security since our database is not directly interacted with. Furthermore, it also allows us to also validate any user information before storing it in the database.

Robustness, reliability and fault tolerance must also be accounted for in the design. One of the benefits of containerisation in these categories, as if a fault occurs, the individual container containing the broken component can be restarted or fixed independently from the rest of the system. This means that the uptime of the system as a whole is less likely to be damaged, and if it is it will be down for a shorter period of time.

Modularity and reuse, and extensibility are further important design components. Modularity is largely implemented by splitting the architecture up into two sections: the frontend and the backend. These can then be developed largely separately, relying on a predefined API to communicate with each other, then integrated together later. This also improves extensibility, for example as new frontend designs can be added without changing the backend by using pre-existing API calls.

Correctness is the final aspect which we consider in the design. Correctness of complex systems is much more arbitrary than of simple algorithms. For example, an algorithm could be formally proved to always give the correct output given any input, but a complex system can only be shown to satisfy its requirements. This is done by comprehensive testing of every component in the system, known as end-to-end testing - and is discussed in our testing section.

3.3 Technologies used

A fundamental decision in the project is deciding which technologies should be used to compose the so-called "tech stack". Since this is such an important set of decisions, we carefully considered a number of options with respect to a set of criteria which assess the quality of a component technology choice. These criteria include:

- Suitability, how well does the technology match the problem our system solves?
- Documentation and popularity, does the choice have strong documentation and an active community likely to have already answered problems we may encounter?
- Consistency, how well the choice meshes with the other component technologies?
- Performance, will the technology run sufficiently fast, and can it be scaled later needing to switch to something else more performant?
- Experience, how much prior knowledge does our team have of the technology?

Category	**Choice**	**Justification**
Application type	Web app	Suitable as it is portable and compatible across devices, since it is run in-browser, and can be designed to support differing view widths such as mobile. All of the team has experience with web design.
Backend framework	Django	Suitable as it facilitates fast development, needed for prototyping, and inherently supports non-functional requirements of security and scalability, and it is popular. Because of this, it has consistent integrations with other categories. Based on python, which team has experience with.
Web server	NginX	Suitable as it serves static web content effectively, and is an industry standard. More performant than its competitor apache. Consistent with Django backend in common technology stacks
Frontend framework	Vue.js and Bootstrap	Since we are making a web application, we will use HTML/CSS/JS. We decided to use the Vue.JS framework to develop the frontend, as it facilitates writing responsive websites, but has a much less steep learning curve than other frameworks, and is known to integrate well with Django. Using a framework, provides us with powerful tools that allow us to develop the frontend quicker than if we did this project without it. Furthermore, we are going to use bootstrap as the CSS framework as it allows us to quickly develop a professional looking website with little hassle.
Database	PostgreSQL	Suitable as it is a relational database, which fits the type of data we need to store, e.g. user accounts, calendars, etc. and it is popular. It has very strong documentation compared to other SQL flavours, It is consistent, as it has a good integration with Django. All of the team has experience with it from a previous module
API	JSON REST	Suitable as it facilitates the access of only the required data. It is incredibly ubiquitous, as it is a subset of Javascript, and hence is consistent with our Vue.js framework. Both our backend and frontend team members have experience with it, which is crucial as it will form the link between the two sides of the technology stack

Container-isation	Docker	Suitable as it is the de-facto standard for containerisation (57% share), so strong documentation and an active community. Consistent with all of the other technologies.
Version control	git with GitHub	Suitable as it is full featured, supporting branching for collaboration, remote backups, and CI/CD through GitHub actions. Industry standard, so strong documentation and an active community. Consistent with all other technologies. All of the team has experience with it from a previous module.

When deciding on our technologies, we considered using some form of machine learning in the project - specifically for the matching system for mentors and mentees. However, we decided against doing this for a number of reasons. We thought that an algorithmic solution would produce better solutions, given the varied type of metrics that are recorded, and the fact that not enough data points on what a good match entails would be recorded to adequately train a model, as mentoring relationships are likely to last years at a time. However, we did decide to use sentiment analysis on feedback, as more (helpful), data metrics almost always improves prediction quality of an algorithm. We plan to use the python library NLTK to implement this, as it is consistent with our python backend, and an industry standard for this type of application.

3.4 System architecture

Our system architecture follows the MVC (Model View Controller) architecture which is a well-known model to be successful in creating a system that presents data obtained through a controller that interacts with the database. This is reflected in the Docker containerisation figure with our website being the view, the Django system being the controller, and Postgresql as the model. Being modularised to 3 separate components, allows easy distribution of development, with each focusing on a subset of skill sets. One downfall of this architecture is that the system is tightly connected in that if one system fails, the rest falls - however we believe that this is outweighed by the benefits of this architecture. Furthermore, the fact that it is a trusted design pattern suggests it is not an inherently problematic approach. A REST API will be used to serve data to the user, allowing both static site pages and dynamic JSON data to be served from the Django backend.

We decided to containerise our model, as the specification stated that Deutsche Bank already uses containers for this type of application, so it will provide modularity within their existing systems. Furthermore, it gives the property of easy "lift-and-shift", meaning that all the dependencies can be handled within the containers, which themselves are portable and compatible across machines.

We decided against using microservices, instead opting for a monolithic architecture. This was predominantly for two reasons: Django has a higher overhead than other backend frameworks like Flask, so making multiple microservices can reduce performance; and there is not a clean way nor a good reason to split the internal logical model into separate microservices.

When designing our system architecture, we took into account the "twelve factor application" principles. For example using a workflow based around git to fulfil the codebase and release principles, or using docker to fulfil the dependencies, and port binding one.

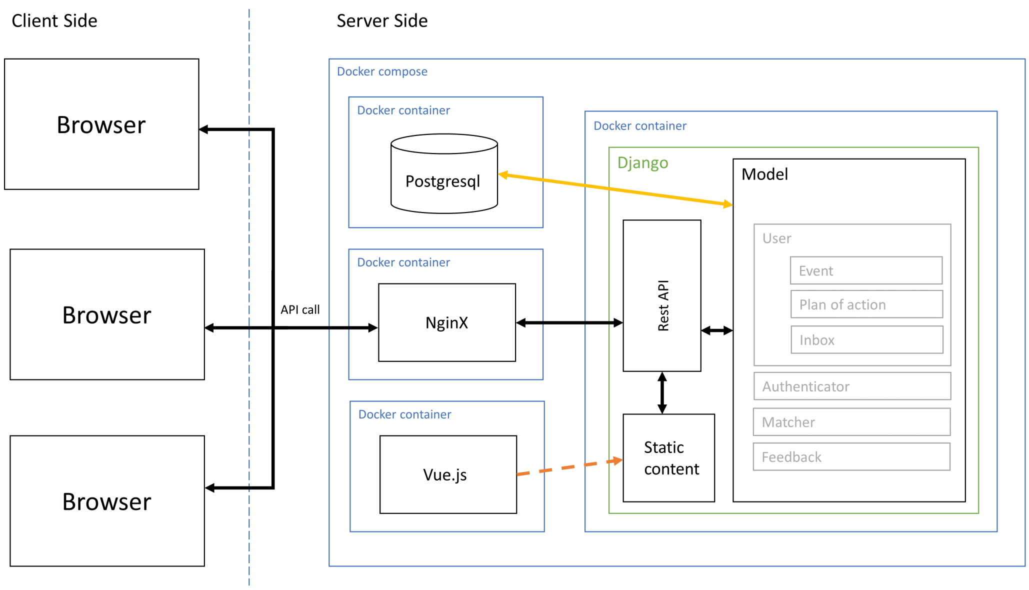


Figure 2: A system diagram of our system architecture.

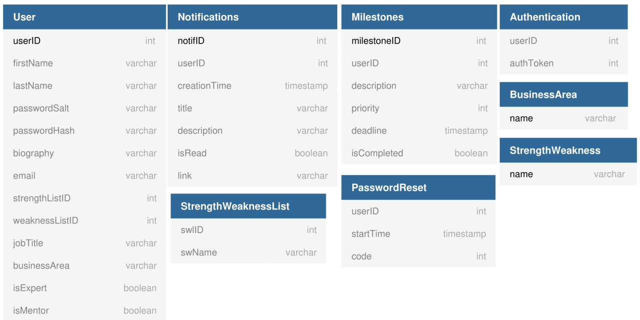
The containerisation has two distinct parts. The first is the three containers dynamically interact with each other based on user requests, with the NginX container serving requests into the Django backend container, which runs the internal logic, and can look up data from the postgresql database container. The second is the final container which generates the static site content from Vue.js to pure HTML, CSS, and Javascript. This is then copied into the Django container so it only needs to be generated once, not on a request-by-request basis.

3.4.1 Database Design

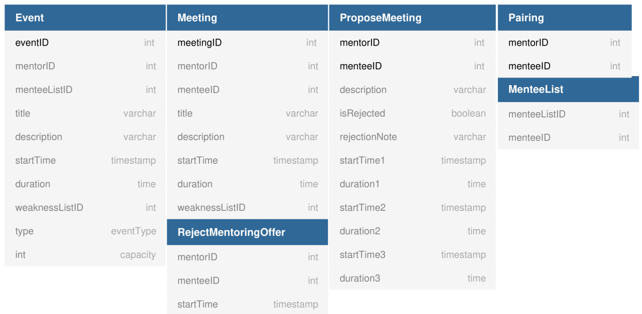
The User table stores relevant user information required by the overall system. BusinessArea and StrengthWeakness tables lists all possible options the user may choose as it is not free text. PasswordReset should only have unique userIDs to ensure there is only one reset code, and should be removed if it has expired. Notifications and Milestones will be searched by userID to obtain a user's relevant data entries. Authentication stores a token to be matched with what is stored in the user's cookies to reduce the number of logins as it can be annoying for users.

Pairing table reflects the current mentor-mentee pairings between users. Important constraint is that a userID must be unique in the menteeID column since mentee's can only have one mentor. Event table is different from a meeting in that it has multiple mentees, a capacity of number of people that can join and a type - GroupSession or Workshop. ProposeMeeting can only store one proposition for a meeting at a time relative to a pairing. If the mentor rejects, it is reflected by a boolean and a note for the mentee. RejectMentoringOffer is expected to be used in suggestion lists, to temporarily hide a mentee in the case that mentee rejects a mentoring offer (F08).

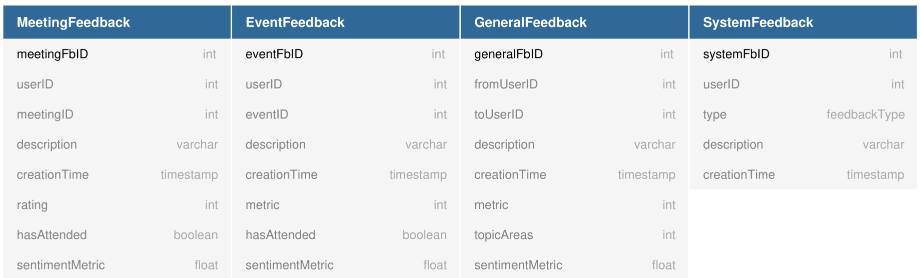
Feedback has been decomposed to 4 types. To ensure efficiency and scalability, each type of feedback has its own table rather than trying to abstract commonalities, creating dependencies that could be problematic in the future. The difference between MeetingFeedback and EventFeedback is if it's for a meeting or event. General Feedback stores overall feedback to a mentor by mentee. These 3 will store an analysis of its sentiment, that will be used in the suggestion process. SystemFeedback has two types, error or feature that is used by developers to improve their system.



(a) The user tables schema.



(b) The mentoring tables schema.



(c) The feedback tables schema.

Figure 3: Table schemas of groups within our systems' database schema

The three subgroups shown in the above figures all relate to each other in the way shown in the final figure. This is done to make the complex schema more easily parsable, whilst retaining detail.

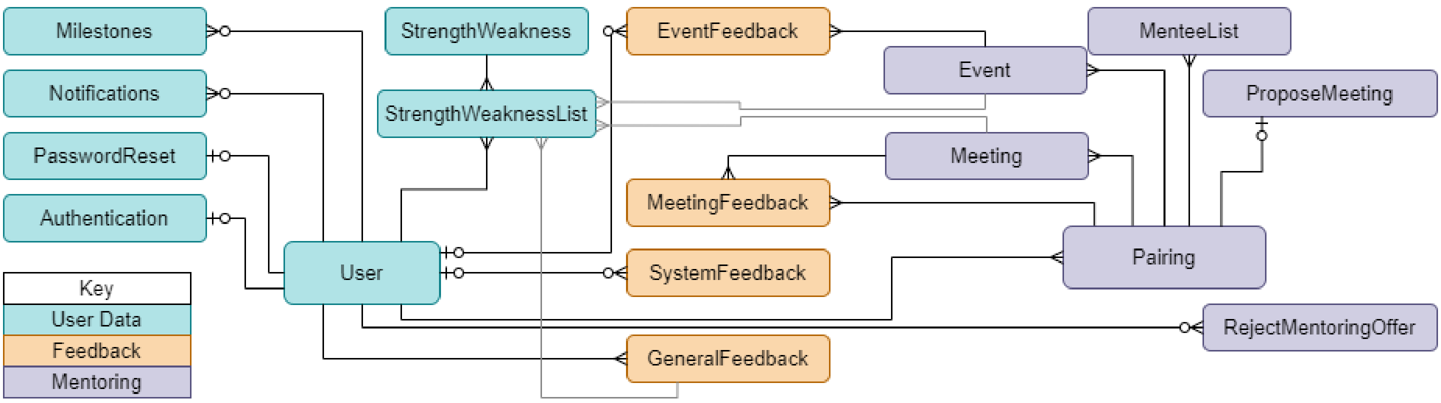


Figure 4: Entity Relationship Diagram.

3.4.2 Object Structure

We've decided to take an object oriented approach on the back-end side of the application. This allows us to separate the problem into multiple smaller subproblems which can be solved one at a time. It also allows for different team members to work on different sections of the back-end code simultaneously, thus improving our team's efficiency; each back-end developer will be assigned a set of classes which can be worked on independently. As shown in the class diagram, we've utilised inheritance wherever suitable. This reduces the complexity of the problem, and means that we'll have to write less code overall, therefore saving time for our backend developers—something that is especially important when considering the short timescale of the project. The object oriented approach is particularly useful when trying to model the problem as a whole. The use of techniques such as aggregation and composition, help model the relationships between objects in the system, giving us a greater understanding of how data will flow.

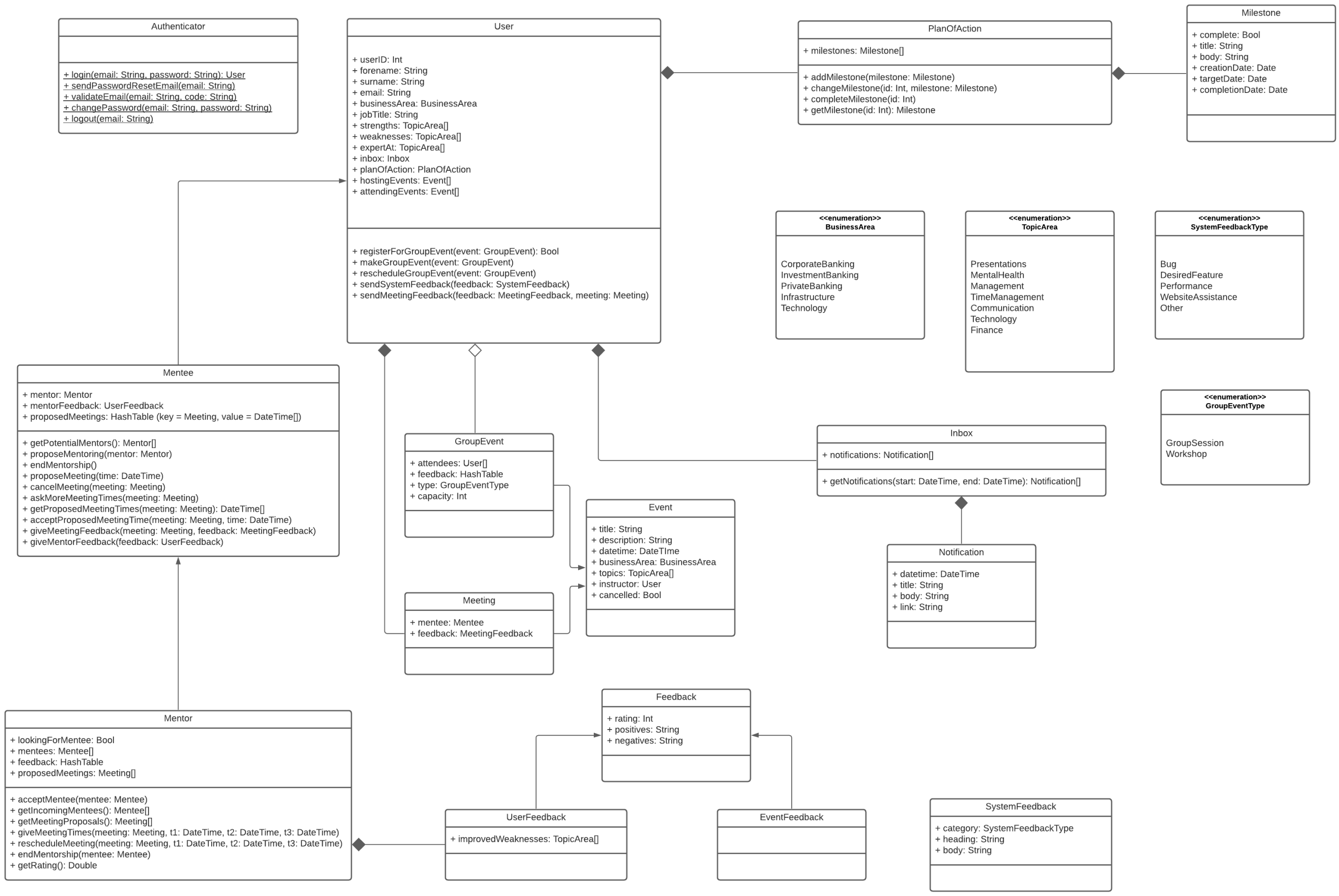


Figure 5: A UML class diagram of our object structure.

3.4.3 API design

We have planned to design an API which will be used by the front-end to interface with the core back-end components of the system. We've decided to settle on a REST API implementation, as it emphasises client-server decoupling, which will make it easier to separate front-end and back-end tasks between our developers—something which is of the utmost importance when working in a smaller, less experienced team. The REST API system will give the front-end developers access to fixed API endpoints, which will act as a bridge between the front-end and back-end of the application. The front-end developers won't need to know how these endpoints are implemented, they only need to know what functionality they provide. This will save development time as developers can now focus on their specialties. This modular way of designing the API allows for back-end code to be modified without having to consult the front-end developers about potential consequences. As long as the specification is followed, a back-end modification should have no effect on how the front-end developers interact with the system. Overall, this will save time as unnecessary communication between developers will be eliminated.

Resource	**HTTP method**	**Description**
register	POST	Registers the user. A newly created user ID is sent in the response payload. A session ID will be in the response header, to be stored as a cookie.
login	POST	Logs the user into the application if the email and password match. The user ID is sent in the response payload. A session ID will be in the response header, to be stored as a cookie.
resetPassword	PUT	Resets a user's password.

getProfile	GET	Asks the server for a user's profile information (user ID will be specified). The profile information is then sent back in the response payload.
getPotential-Mentors	GET	Gets a list of potential mentors for the mentee.
selectMentor	POST	Indicates that the mentee wants to be mentored by a particular mentor from the list of potential mentors.
getRequested-Mentees	GET	Gets a list of mentees which have requested to be paired with a particular mentor.
acceptMentee	POST	Used by a mentor to indicate that they want to begin a relationship with a particular mentee.
getMentor	GET	Gets the mentor of a particular mentee.
getMentees	GET	Get a list of the mentor's mentees.
terminateRel-ationship	DELETE	Terminates a mentoring relationship. Feedback for termination is provided in the request.
proposeMeeting	POST	Allows the mentee to propose a meeting.
proposeMeeting-Times	POST	Allows the mentor to send a list of potential meeting times back to the mentee.
acceptMeeting	POST	Allows the mentee to accept one of the meeting times proposed by the mentor.
reproposeMeet-ing	POST	Allows the mentee to ask for new meeting times.
cancelMeeting	DELETE	Gives feedback for a particular meeting.
getMeetings	GET	Get a list of scheduled meetings.
giveMeeting-Feedback	POST	Gives feedback for a particular meeting.
getPlanOfAction	GET	Get details of the plan of action.
addMilestone	POST	Adds a milestone to the plan of action.
setMilestone	PUT	Changes the content of a milestone.
completeMile-stone	POST	Set a particular milestone to complete.
getMilestone	GET	Get information about a particular milestone.
setMentorFeed-back	PUT	Allows a mentee to update their current feedback on their mentor.
createGroup-Event	POST	Allows a mentor to create group sessions or workshops. The type of event is specified in the request.
getGroupEvent	GET	Get details about a particular group session or workshop.
joinGroupEvent	POST	Allows a user to sign up for attending a group event.
getNotifications	GET	Gets notifications for a users' inbox, with the date range being specified.
submitSiteFeed-back	POST	Allows users to give feedback about the site.

4 UI/UX design

4.1 Page Hierarchy

The page hierarchy below displays the sites that our webpage comprises of. Here is a brief outline of what each page will consist of:

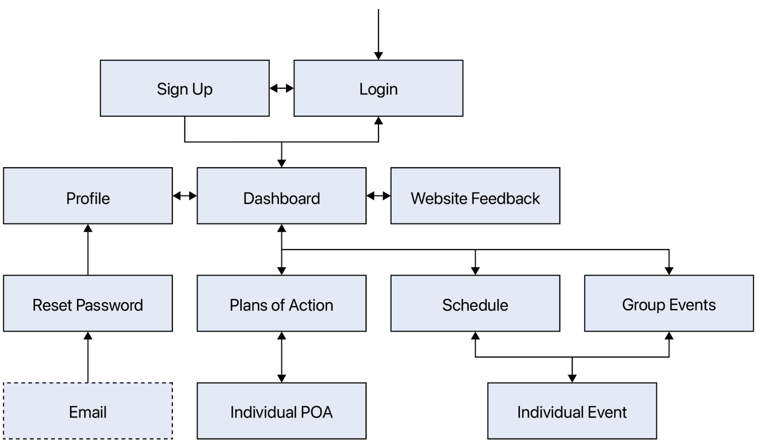
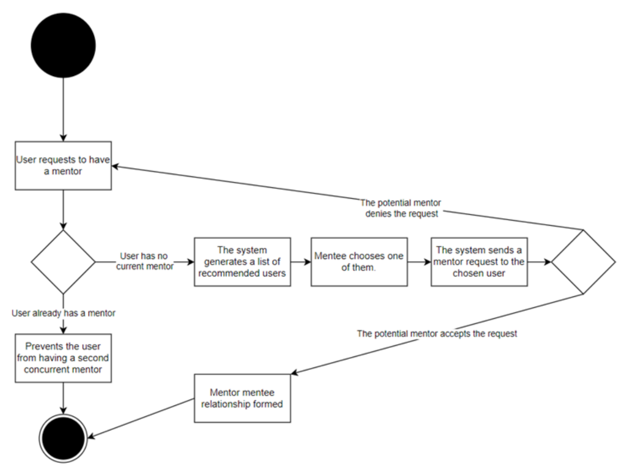


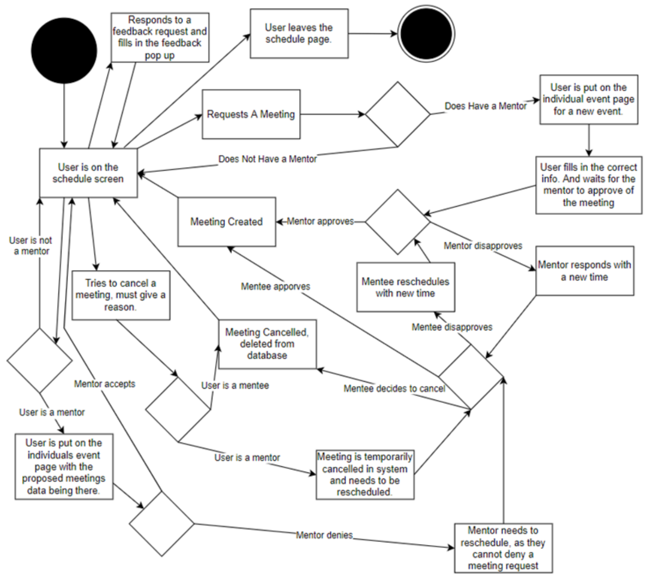
Figure 6: A diagram of website page hierarchy.

- Login Screen: The landing page of the website that allows the user to login to go to the dashboard or the sign up page to create an account.
- Sign Up: Allows the user to create an account.
- Dashboard: The central hub for the user where all pages can be accessed from and displays useful information that may be useful (look at page designs for more detail).
- Profile: This page has 3 purposes: resetting the users password, seeing the users data and modifying the users data.
- Plans of Action: Displays the users plan of action and their mentees plans of actions too if they have any.
- Individual POA: If the user clicks on a POA, then they come to this page where the POA can be viewed and modified.
- Schedule: Shows the users schedule, allows them to request meetings and has a list of feedback and meeting requests that the user should respond to.
- Group Events: Allows the user to search for workshops and group sessions within the system that they can attend.
- Individual Event: A page that details an event (meeting or group event) and allows the owner of an event to modify or delete the event.

4.2 User-system interaction



(a) A diagram of the states required to match a mentor and a mentee.



(b) A diagram of the states required to schedule a meeting.

Figure 7: State diagrams for some aspects of our design.

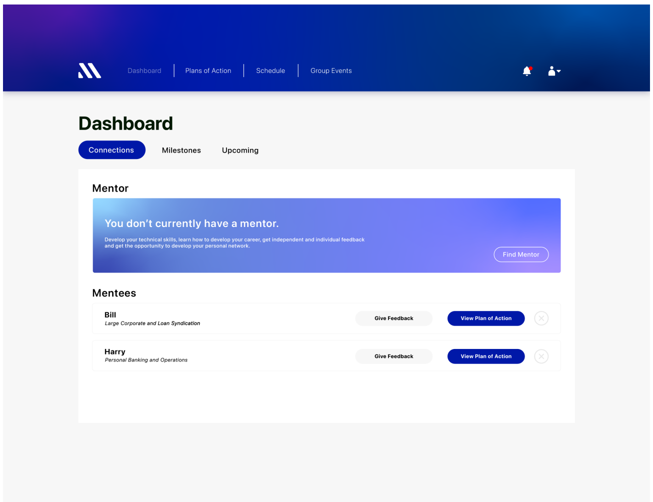
The specification was very vague about how to match up mentors and mentees. The left diagram provides a visual representation of how exactly we interpreted it in our requirements.

- The user can only have 1 mentor at a time
- The system can give the user a list of potential other users who are currently looking for mentees
- The user then picks one of these users and a mentor mentee request is sent to the potential mentor
- If the potential mentor accepts, then a relationship is formed
- Otherwise, the mentee needs to choose another mentor from the list

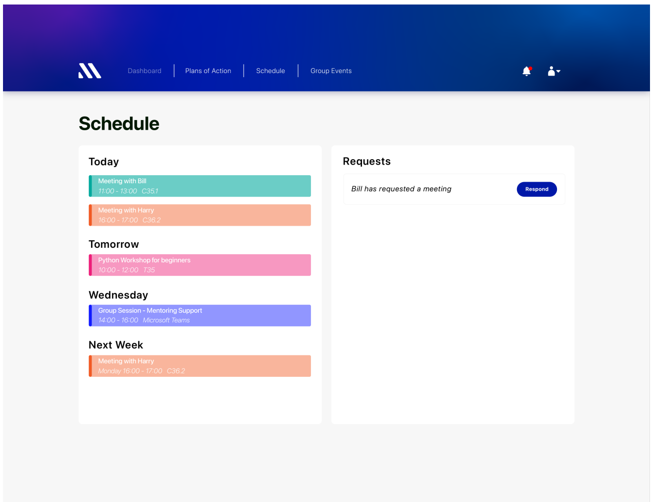
The right diagram displays what functions the Schedule page has. This handles a lot of ambiguities around how the meeting and feedback system will work within our system.

- Mentees can cancel meetings, but mentors can only reschedule
- Mentees can request a meeting, but mentors cannot not
- For a meeting to be officially approved, both parties need to agree on the time and date otherwise they go into this loop of suggesting times to each other
- The user will be prompted on the schedule page to give feedback to recent events they have gone to

4.3 Page Design



(a) The initial design of our system dashboard.



(b) The initial design of our system schedule page.

Figure 8: Pages from our initial UI designs

The dashboard is the central page for users that displays all the useful information for the user, such as their upcoming meetings, their current plan of action and allows them to get a new mentee or mentor. The navigation bar at the top of the page will be on most of the pages and will allow the user to access all the other pages of the website as well as their notifications. The notifications inform the user about any recent events that they may be interested in such as giving feedback about a recent event or a mentee/mentor meeting coming up. The drop down button next to the notification bell will link to the user's profile page, the website feedback form and a sign out button.

The schedule page will have the users calender and all the requests the user has (meeting and feedback). This user is not a mentee so the request meeting button at the bottom is currently missing, but if the user was a mentee then there would be a request meeting button at the bottom. Additionally, clicking on a meeting will take the user to the individual event page for the meeting which will have the feedback log for the meeting.

5 Testing

5.1 Test cases

Test cases	
C0. Verify that the user will be able to create an account by providing correct details; which would be added to the database.	C15. Verify that general feedback when given is stored into the database.
C1. Verify that the user will be prompted to begin the tutorial for the website.	C16. Verify if there are sufficient users with common weaknesses, an expert will be prompted to create an event.
C3. Verify that the user can change their password via email, after which it would update their details on the database.	C17. Verify that events can be viewed by users with relevant weaknesses on their home page.
C4. Verify that users can access and make changes to their profile through their profile page.	C18. Verify that feedback can be provided at the end of an event.
C5. Verify if making changes to the profile page that breaks a rule of mentoring will prompt a warning that if the change is made the termination of the user's	C19. Verify that security issues are disclosed to the users.
C6. Verify that users can request for a mentor by checking if an available mentor can see said mentee of their list of pairable mentees.	C20. Verify that the widgets on the home page's dashboard navigates the website as intended.
C7. Verify if mentors can fully view the profile of the mentees that are available to pair.	C21. Verify that the system is intuitive to use and navigate.
C8. Verify if the list is ordered according to the matching metric.	C22. Verify that it is simple for users with no prior technical experience to use the system.
C9. Verify the mentor can likewise send an offer to a requesting mentee if they would like to establish a pairing.	C23. Verify that the system is responsive and has no notable or unnecessary waiting time.
C10. Verify that a prompt should be visible when a mentor does not have a mentee.	C24. Verify that the system can cope with a large number of users.

C11. Verify if mentees can propose a meeting to which a mentor can suggest possible meeting times or which mentees can accept or decline.	C25. Verify that system changes made by developers are visible within a reasonable time.
C12. Verify if feedback is prompted at the end of the meeting and is stored in the database.	C26. Verify that the system clears all unit and integration tests.
C13. Verify that mentees can create plans of actions which are then saved on the 'Plans of Action/Milestones' page.	C27. Verify that the system is secure and protects the users data.
C14. Verify that mentors can access and view any of their mentees' plans of action.	

5.2 Unit and integration testing

Tests will form an integral part of our development cycle, as we plan to follow the agile test driven development ideologies. We will implement this by creating unit tests for all of the above test cases, allowing us to ensure all the required properties of the system are met. These can then be run throughout the development process. All of the tests will be automatically run on a pull request to the GitHub repository, and must pass in order for the code to be merged into the main branch, to ensure its validity. This is an implementation of "continuous integration" from CI/CD, and will be implemented using GitHub Actions.

There are many tools for unit testing which can be used. Since we are using a python backend framework, we will use 'PyTest' for unit tests on the backend code, along with 'codecov' to assess the coverage of the tests, and 'pylint' to ensure that stylistic code is being written. Since we are using a javascript frontend framework, we will use 'Jest' for unit tests on the frontend code and UI, along with 'ESLint' to check that the Javascript is correct. Finally, we will use Postman to test that the API serves the correct data. There are relatively few tools for integration testing, and it will likely mostly have to be done by hand. We will use the 'Puppeteer' tool to automate this task as far as possible. The combination of all of these tools allows us to create a testing suite which will fully cover our system.