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STEM Activity Manager Application with Dual Authentication using One Time Password (OTP)

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Abstract*:* Science, Technology, Engineering and Mathematics (STEM) education is needed to produce quality and sufficient human capital in STEM to drive the economy. In Universiti Tun Hussein Onn Malaysia (UTHM) there is a STEM committee that is to promote STEM among middle and lower form schools. However, Fakulti Sains Komputer dan Teknologi Maklumat's (FSKTM) STEM committee does not yet have a computerized system to manage STEM activities. The committee uses a physical document system and manages the activities through WhatsApp, the current method used is not very systemized. These processes can be very inefficient and confusing, it is very easy to make a mistake and increase the workload on the committee members. The application is an activity manager that can store, edit, and update activities. The system is developed into two user types, the user and the admin. Each module has different functions and modules. The admin and the user can both update and add activities, they can also see their account details, update their details and change their password. The user can add new activities, see pending activities, see rejected activities and see the current progress of approved activities. The admin can see what new activities that need to be approved or rejected, see all the activities progress and set their progress as in progress or completed. Admins can also manage users, they can see a list of current users, reset user passwords, and delete users. The android-based application is created using Thunkable React. The application development implementation is using the Prototyping Development Model.

Keywords: Android, Multifactor Authentication, OTP

1. Introduction

STEM is an abbreviation for Science, Technology, Engineering and Mathematics. It is a program that is supported by the Ministry of Education with the aim to strengthen STEM education as to produce quality and sufficient human capital in STEM to drive the economy. STEM education is to produce

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STEM literate students who can identify and understand problems, as well as applying and integrating STEM concepts into the solutions accordingly. STEM literate students should also be creative, innovative, and inventive in line with the skills needed in 21st century and Industrial Revolution 4.0 [1]. The main objectives of the initiative are to:

- To increase students' interest in STEM through either formal or informal learning means.
- To sharpen the teachers' knowledge and skills in educating STEM subjects through continuous professional development programs.
- And to increase STEM awareness and culturation among students, teachers and the community.

In UTHM there is also a STEM committee that is to promote STEM among middle and lower form schools. However, FSKTM STEM committee does not yet have a computerized system to manage STEM activities. Thus, the proposed application will introduce a computerized system for a STEM application manager that is able to store and display the activities. The Objective to achieve in this proposed application is:

- To design a STEM manager system for the FSKTM STEM committee with 2 Factor Authentication using OTP.
- To develop the proposed system on an android-based platform.
- To test the system with STEM FSKTM coordinator and committee members.

2. Related Work

2.1 STEM Education

In the education system the elements of Science, Technology, Engineering, and Mathematics are defined by Reeve (2015) as; science is a study related to nature, while technology serves as a tool to change the natural world to meet the needs and wants of society. Engineering uses mathematics and science to produce technology in which Mathematics represents the language of numbers, patterns, and relationships that relate to science, technology, and engineering as a whole [2].

The Malaysian Ministry of education (MOE 2016) defined the STEM concept in Malaysia into three: STEM field, STEM stream and STEM approach. STEM field is the traditional disciplines such as Science, Chemistry, Mathematics, as well as the specialized ones. STEM stream is the enrolling of students in upper secondary school to a stream of their choice and inclination. Meanwhile, STEM approach is to solve problems in the context of daily, community and environment life through inquiries and problem solving with the application of knowledge, skills and values of Science, Technology, Engineering, and Mathematics [3].

2.2 Authentication

Authentication is the process of identifying a user's identity or entity before interacting with the system or software [4]. It is the one of the most important aspects of cybersecurity being authentication, security, and confidentiality.

2.2.1 Multi Factor Authentication

Multifactor authentication is the act of using multiple authentications of different credential categories, such as the knowledge factor, the possession factor, and the inherence factor [5]. The aim is to layer multiple defenses so that an unauthorized person cannot access a system or database, these measures should also deter and increase a hacker's job difficulty. So should one factor fail, the other is still there to provide security. The STEM application manager system will use the most common MFA which is 2 factor authentications (2FA) using a password and OTP.

2.2.2 Authorization

To perform a cryptographic function, sensitive action, request, or service using granted access privilege given to an entity is what authorization is defined as [4]. This is an important aspect of security because what data you can access is determined by it. Role-based access control (RBAC) is a role-based security method that restrict and controls system access [6]. RBAC has the advantage of giving administrators increased visibility and oversight on the system, it determines the level of access a committee have so that sensitive information is not accessed easily. It can decrease the chances of data breaches and leaks due to sensitive data access restrictions.

2.3 Comparison of Existing Systems

Drag is a task management platform that works in Gmail and directly turns Gmail into a workspace. It turns Gmail into a fully functioning task manager that can run an entire workflow and project in a user's inbox. It can create a shared inbox that can manage email enquiries from customers or team members or create tasks to do with deadlines. It uses a freemium business model, the basic feature for personal use is free, however for the shared boards and inboxes feature requires a subscription fee.

nTask is also a Task manager software that combines the features of a project management into one software. It has its own stand-alone application software that allows remote collaboration hub designed to manage projects, goals, communications, and teams all in one place. It also uses a freemium business model with a basic usage of maximum team members of 5, any more features will require a subscription. It has mobile support.

Table 1: System comparison between existing systems

System	DragApp	nTask	Proposed System
Secure Login using OTP	No	No	Yes
Admin Module	Yes	Yes	Yes
Activity Management	Yes	Yes	Yes
Activity tracking	Yes	Yes	Yes
Deadline Management	Yes	Yes	Yes
Role-Based Access Control	Yes	Yes	Yes
Platform	Web Android	Web Android	Android

3. Methodology/Framework

The prototype model is used as the project's development life cycle. A prototype model defined by Naumann and Jenkins (1982) is a system that captures the essential features of a later system, is essentially incomplete, to be modified, supplemented, or supplanted [7]. This method involves user involvement and feedback about the functional requirement of the software prototype to assist in problem understanding and problem solving. The prototype is created based on current requirements to give the customer an understanding of the system's desired requirements. The prototyping method simultaneously performs the planning, analysis, design, and implementation in a cycle continuously.

3.1 Planning Phase

The planning phase determines the objectives, problem statements, scope, and project importance. The literature review is done on some requirements needed for the project to exist. The methodology was also made to determine proper flow of activity and project development path.

3.2 Analysis Phase

The analysis phase determines the project's software development by analyzing hardware and software requirements by analyzing and comparing existing systems and its problems.

Table 2: Functional requirement for the system

No.	Modules	Functionalities
1.	Login - Admin - Committee member	- System alerts for any invalid inputs. - User inputs valid ID and password
2.	Profile - Admin - Committee member	- Allows users to update details or create new password. - System alerts for any invalid inputs.
3.	Manage activities. - Committee member	- User can add and update activities. - User can see a list of activities.
4.	Manage users. - Admin	- Registers new user or remove users. - manage user details.
5.	Manage activities application. - Admin	- Admin can add or remove activities. - See a list of activities. - Admin can approve or reject submitted activities.

Table 3: Non-functional requirement analysis

No.	Requirements	Description
1.	Performance of the user interface and dataflow	- System should be able to correctly locate session
2.	Operational	- The system can only be accessed when online. - The system is only available on android platform.
3.	Security	- User may only access account using username and password. - the password must be encrypted using AES. - password must be a certain length of alphabets, numbers, and symbols to meet minimum security requirement. - The system must use multi authentication

3.3 Design Phase

The design phase determines the project's system design. The system interface, database and architecture are designed. The systems schema table, user interface and prototype designs are formed. Figure 1 shows the system's architecture on how the system works. The user must first interact with the login page, to access the homepage. Which will display user profile and the activity manager. Users can choose the activity manager to see activities list, add activities and edit them. User profile allows user to see their profile, they can update and change their password, name and phone number.

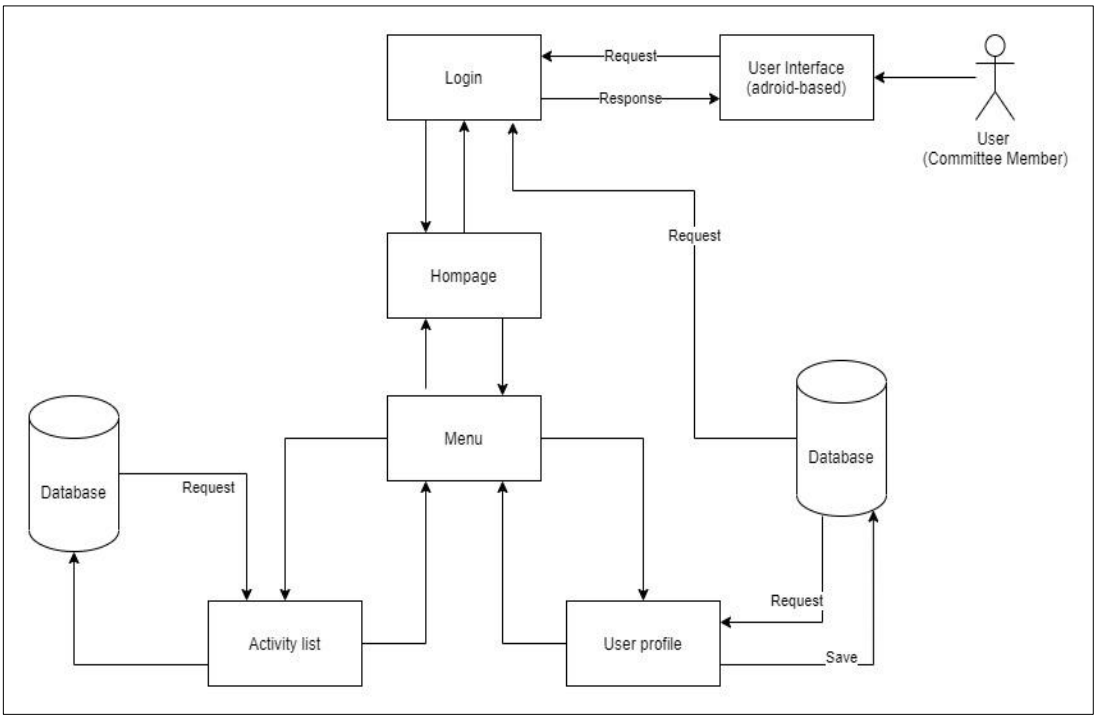

Figure 1: General architecture of proposed system

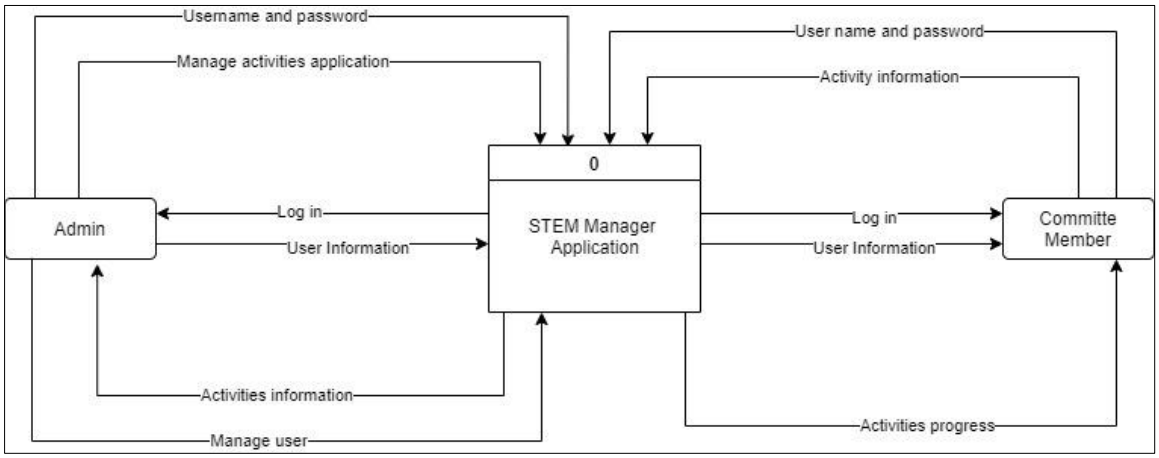

Figure 2: Context diagram

Figure 2 shows the context diagram for STEM Manager Application. In the diagram, every process between committee member and admin will be done in the manager application.

- Admin entities can receive user information from the central process. Admin can manage user profiles, remove, or add users, and manage the activities application. Admin can add activities, approve, or reject activities.
- Committee member entities can manage activity, committee members can add, update or delete activities, and view activities.

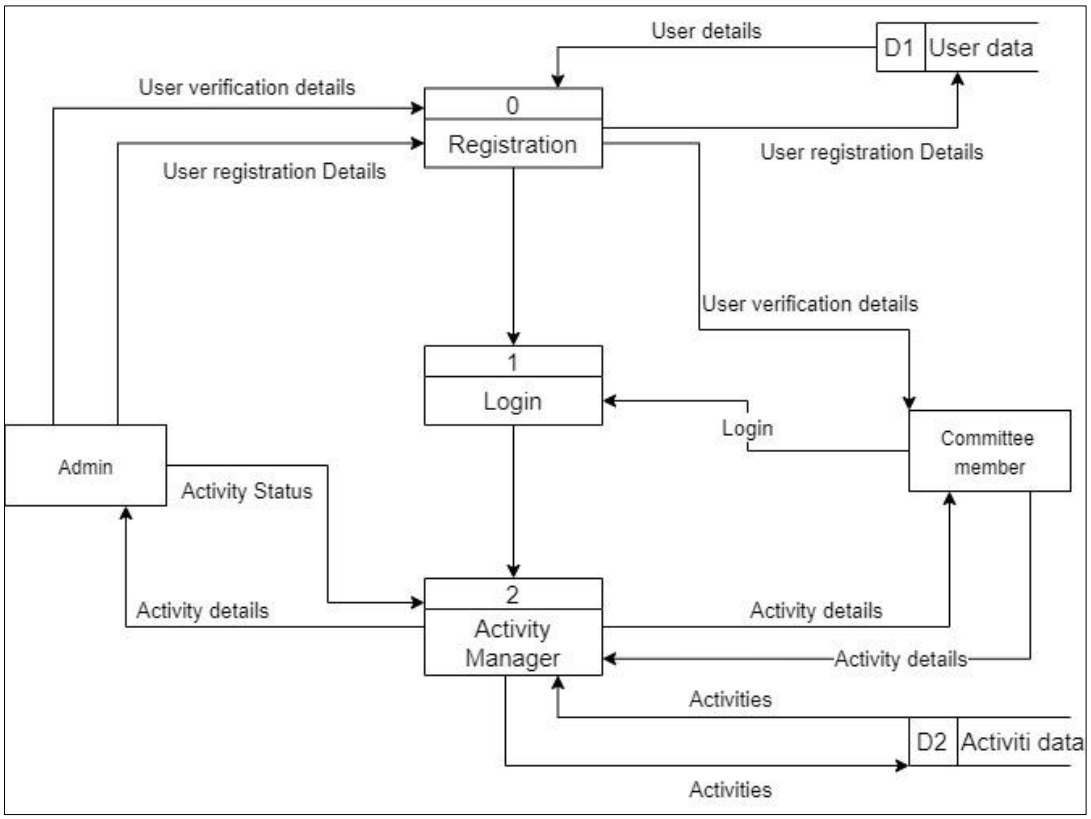

Figure 3: Level 1 Data Flow Diagram

Figure 3 shows the processes at work within the system, the processes that are within the system are Registration, Login and Activity manager. The data flow of activity data which contains the activity details, user data which contains the user login details. Figure 4 shows the entity relationship diagram of the proposed system.

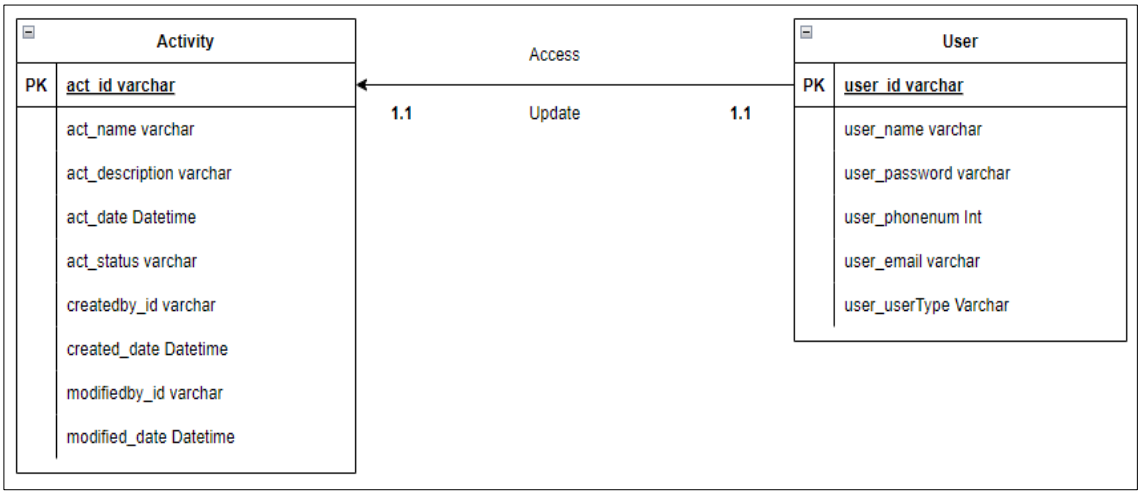

Figure 4: Entity relationship diagram (ERD)

Figure 5: Login interface

Figure 5 shows the design of the login page. Both committee members and the admin need to enter the correct email and password to access the system. If there is an incorrect email or password or there is no account, they cannot access the system.

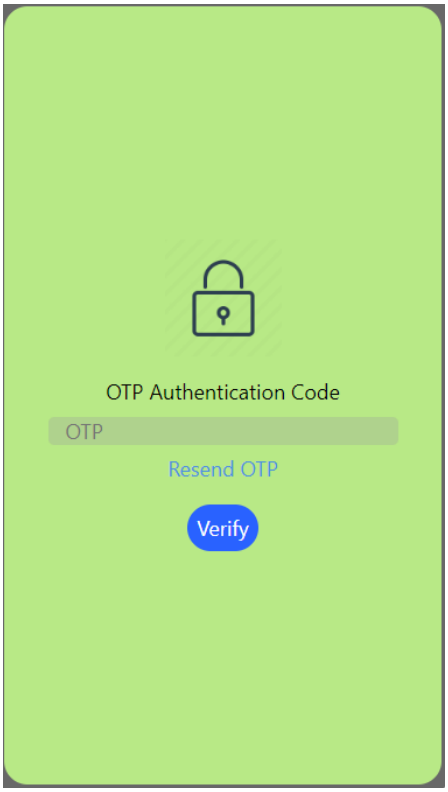

Figure 6: OTP interface

Figure 6 is the interface for the OTP page that after a successful login using email and password, they need a second authentication using a One Time Password (OTP). A unsuccessful authentication will not allow a user to access the system.

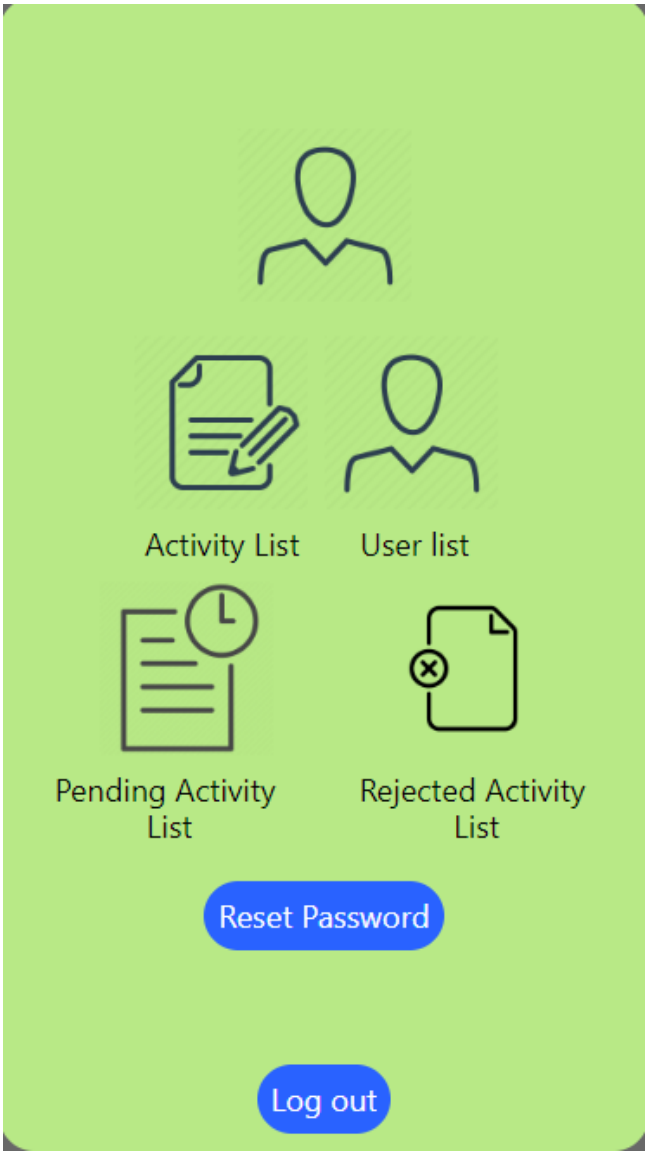

Figure 7: Homepage Interface

Figure 7 shows the main page after a successful login. The above is for the admin, a normal user has a similar layout just without the user list. The user can choose to see the activity list, which they can see the current approved ongoing activities and they can add new activities. The admin can see what added activities they can approve or rejected while the normal user can see which activities are currently pending. Both user and admin can see what activities were rejected.

Figure 8: Activity interface

Figure 8 is the activity interface which allows a user to see all the current ongoing activities. The user can also see selected activity details and can update them.

3.4 Implementation Phase

Implementation phase is the creation and implementation of the prototype which is created using Thunkable as the compiler for both back-end and front-end development and Airtable as the database platform. The prototype is then simulated to be shown to the user. User review and feedback will be given and from that, repeating back to analysis phase to update requirements. After the analysis, the design and implementation of an updated prototype until it satisfies user requirement of the prototype.

3.5 Testing Phase

The testing phase is done after the implementation phase, it has two parts, alpha and beta testing. Alpha testing is done by the developer and beta testing is done by the user. This is to find any weaknesses, bugs or errors that can be improved upon in the next prototype.

4. Implementation and Testing

Using analysis and design from the previous chapter to build a prototype that implements the User and Admin Modules. The coding platform used for the prototype creation was Thunkable, which is used for both back-end and front-end coding. Thunkable uses coding block instead of the traditional compiler.

The database platform used was Airtable due to it being a cloud platform. Early testing in parallel to implementation is done to find as many problems as possible.

The system will have two parts, one is the user interface that users will be interacting with and the backend coding that will run the system's process and logic. The user interface is a platform that allows the user to interact with the system in an easy and efficient way for the STEM Manager Application with Dual Authentication Using OTP. Figure 9 is a code snippet using Thunkable block coding with the function of sending a random six pin code to a user email for authentication.

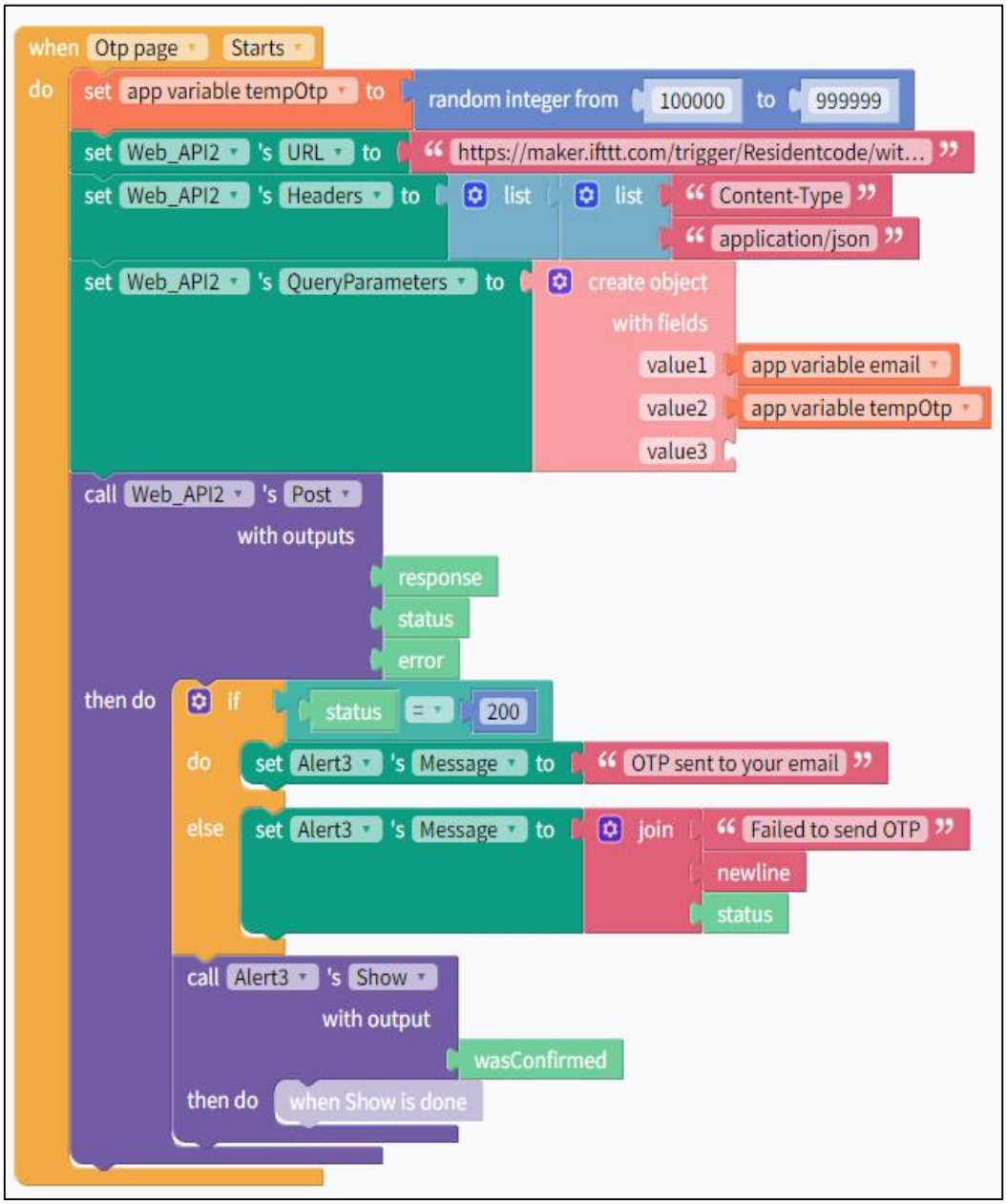

Figure 9: Implementation for the OTP

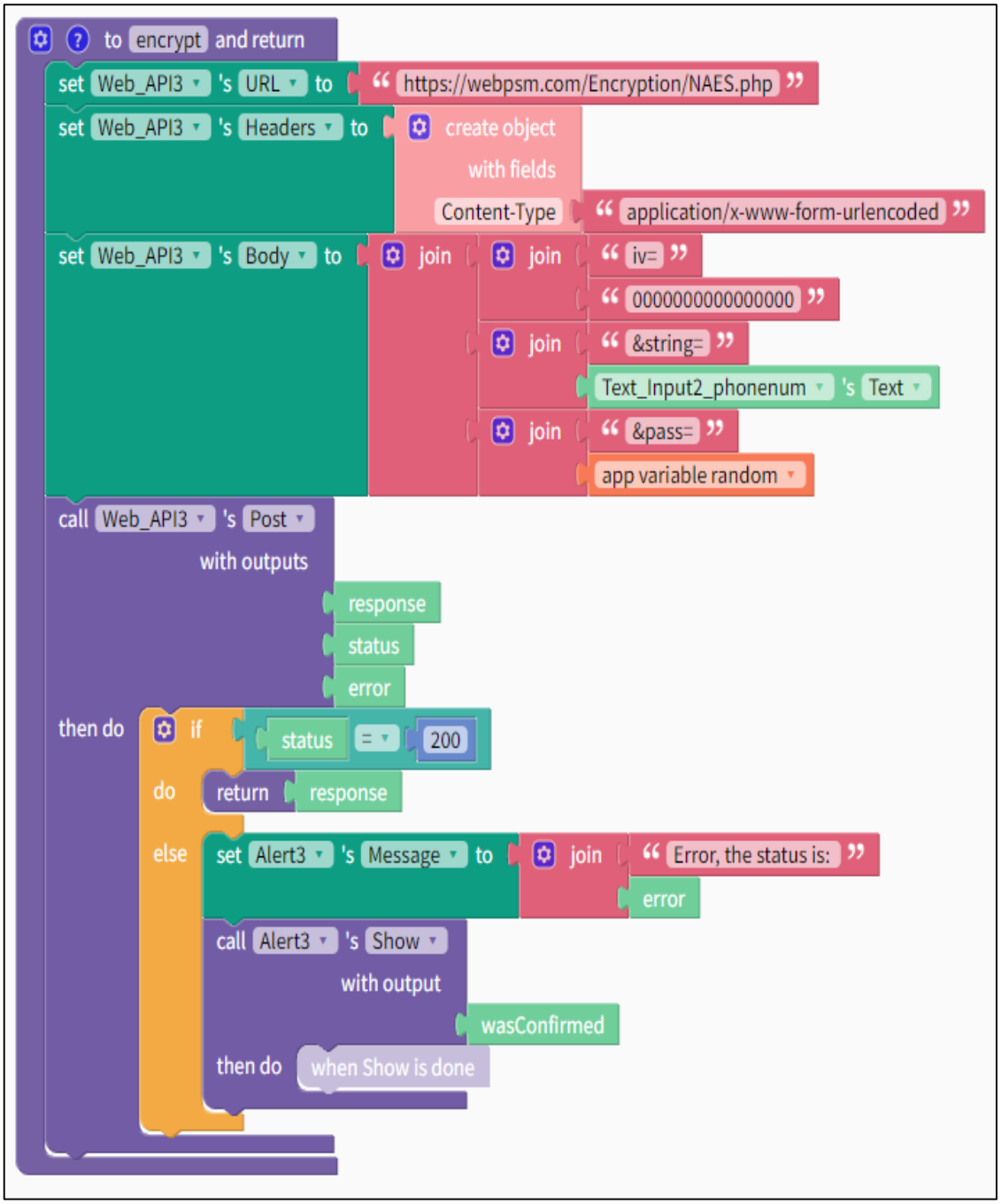

Figure 10: Implementation for the encryption

Figure 10 shows the implementation of the encryption within the system. It uses AES encryption using PHP using the web api component within Thunkable. It sends the password to the URL which then encrypts the password sent and returns the hashed password.

4.1 Functional Test Plan and Results

The testing phase involves a variety of tests to ensure the program accuracy in its processes and logic. Tests in functional reliability in anticipation of system operation. Complete testing is done to ensure that the developed system meets the systems' requirements and specifications. The two types used for this are the system functionality testing and user acceptance tests as shown in Table 4.

Table 4: Functional Testing of modules

No.	Test case	Expected Output	Actual Output
1.	**Functional Testing of Login and OTP module**		
1.1	Complete and valid inputs	The log in and OTP displays a message of successful log in and OTP authorization.	as expected
1.2	Incomplete inputs	A warning about empty input fields will be given and that it will ask to fill the empty inputs.	as expected
1.3	Invalid inputs	An error alert will be displayed for incorrect OTP input or invalid email and password. It prompts to try again.	as expected
1.4	Unable to send OTP	It will display and error message saying that OTP has failed to send	as expected
1.5	Able to resend OTP	The system will send a new OTP code to the users email and prompt reauthorization.	as expected
2.	**Functional Testing of Register module**		
2.1	Complete and valid inputs	The system will display a message saying registration complete. It will then navigate user list.	as expected
2.2	Incomplete inputs	A warning about empty input fields will be given and that it will ask to fill the empty inputs.	as expected
2.3	Invalid inputs	An error alert will be displayed for incorrect email and password inputs. It prompts the user to reenter.	as expected
3.	**Functional Testing of user list module**		
3.1	Valid input	The selected user will have their password reset and an alert will prompt to show the success of reset.	as expected
3.2	Invalid or incorrect input	It alert that the password has fulfil the requirements set for a strong password or that the confirm new password field is not the same with the new password.	as expected
3.3	Empty or incomplete input	An alert will be displayed that the password fields are empty.	as expected
4.	**Functional Testing of users' activity list module**		
4.1	Update Activity Progress	The activity progress is set to completed.	as expected
4.2	Add Activity	It will navigate to the create activity page	as expected
4.3	Update Activity Details	An error alert will be displayed for incorrect OTP input or invalid email and password. It prompts to try again.	as expected
5.	**Functional Testing of Admins activity list module**		
5.1	Update activity Progress	An alert window will show what to set the progress of selected activity to.	as expected
5.2	Add Activity	It will navigate to the create activity page.	as expected
5.3	Update Activity Details	An alert will ask the user if they want to update. If confirmed it will navigate to the details page.	as expected
5.4	Delete Activity	An alert will be displayed for confirmation on deleting an activity.	as expected
6.	**Functional Testing of activity details module**		
6.1	Update activity	User can update Activity	as expected
6.2	Display Activity details	It will display all the details of the chosen activity.	as expected
6.3	Update Activity Details	An alert will ask the user if they want to update. If confirmed it will navigate to the details page.	as expected

Table 4: (cont)

No.	Test case	Expected Output	Actual Output
7.	**Functional Testing of user list module**		
7.1	Reset a users' password	The selected user will have their password reset and an alert will prompt to show the success of reset.	as expected
7.2	Add user	It will navigate to the Register page	as expected
7.3	Delete User	An alert will be displayed for confirmation on deleting a user.	as expected
7.	Reset a users' password	The selected user will have their password reset and an alert will prompt to show the success of reset.	as expected

5. Conclusion

In conclusion, the objective of successfully developing a STEM Manager Application with Dual Authentication using OTP is achieved. The system fulfils the functional and non-functional requirements set during the analysis and design phase; it also achieves the objectives set during the beginning of the project. However, during the development there were several challenges that came up. Several suggestions for the improvements were considered to ensure system improvements.

Several advantages were identified after completion of implementation and testing that was carried out on the system. The identified advantages are that user only need to use their smartphone for authentication using the email OTP. The system has provided the modules register, create activity, activity list, activity details, and user details for the use of the developed system. This system provides an easy way to manage activities and use a committee using a computerized system.

There were several disadvantages that were identified from the current development of the system; Admin cannot generate activity report. Users cannot upload a file or attachments into the system.

Recommendations, other than the advantages and constraints of the system, several suggestions for improvements for the system was acquired from the analysis. Some of the suggestions that were raised; improvement is the admin generate activity report. They can see what activity was completed monthly in a simple interface. Add the ability to add attachments either as pictures or documents for better activity management.

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