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Streamlining Dental Clinic Management for Effective Digitisation Productivity and Usability

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Abstract - Oral health is an integral part of overall health, and poor oral hygiene can lead to a variety of health problems. Modern oral care has greatly improved our quality of life, but the increasing demand for routine dental checkups and treatments calls for improved systems for managing patient records and appointments. While technology has significantly enhanced the efficacy and experience of dental care, many dental clinics still rely on paper records to record the patient's oral condition, but these are not easily accessible to the patients for viewing. This study aims to address the issue by developing a Dental Clinic Management System to manage patient appointments and records. This system will allow patients to manage their appointments, view their dental history, and receive comments from dentists. Dentists will be able to view appointments, perform treatments, and provide feedback to patients, while the administrator or receptionist will be able to manage appointments, view records, and create invoices. By streamlining dental clinic management, this system aims to improve the overall quality of oral healthcare.

Keywords— Dental, Clinic Management System, Appointment, Oral Health, Productivity and Usability

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I. INTRODUCTION

In the ever-changing world, the application of digitalization has become the new norm in the pursuit of having better efficiencies in the work we carry out in our daily lives. Digitalization enables us to carry out the tasks we traditionally associated with the use of paper manually by turning them into digital data to a computer, making the process more efficient and less wasteful. There are still some businesses that still collect data and information using physical hardcopy and have not fully gone through digitalization, one of them being dental clinics.

Currently, dental clinics still rely on physical dental charts made with paper to record the patient's dental information, such as teeth conditions and treatment performed. Moreover, all this information is not available to be accessed and viewed easily by the patients themselves. Prior to this, there had been some research that had investigated implementing an application for recording the patient's dental information [1][2][3][4].

Thus, a web-based Dental Clinic Management System (DCMS) was proposed to provide better experience from the usability standpoint for the patients and the staff working in the dental clinic. It should provide both patients and

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dental clinic staff with a better overview and availability of the appointments, dental records, and treatments performed.

II. BACKGROUND STUDY

A. Oral Heath

A vital sign of general health, welfare and quality of life is oral health [5]. The term "oral health" refers to the health of the teeth, gums, and complete oral facial system, which enables us to chew, talk, and smile. Cavities, gum (periodontal) diseases and oral cancer are some of the most frequent diseases that affect our oral health [6]. According to the study conducted by the World Health Organization (WHO), it's been noted that about 3.5 billion people worldwide are having oral diseases [6]. In 2010, the Ministry of Health Malaysia conducted a survey among adults in Malaysia published that "94% of dentate adults have some form of periodontal diseases" [7].

The factors that affect oral health are closely associated with having unhealthy diets such as consuming foods and drinks that contain high sugar contents, the consumption of alcoholic beverages, and finally the utilization of tobacco products [6].

Practising and maintaining good oral health can lead to a healthier life as it reduces the risk of cardiovascular diseases, cancer, and dementia. It would also help with not having bad breath and would also contribute to having higher confidence when interacting with the people around you [8].

B. Types of Oral Problems

The common oral problems that can be seen impacting our daily lives include cavities, gum diseases, broken teeth, root infection, and enamel corrosion. Cavities, also known as tooth decay, are caused by the acids released by the bacteria in the plague. The acids cause the enamel or root surface of our teeth to erode. The main culprit is consumption of highly sugary foods and drinks [9].

Gum (Periodontal) diseases are mostly caused by gum and bone infections and inflammations that surround and support the teeth. Health complications such as weak immune system, diabetes, poor oral hygiene, and tobacco usage are some of the factors causing it [10]. Broken teeth can be caused by consuming food that is hard, or by accidents such as falling, cavities, and many more [11].

Root infection happens when the pulp of the teeth is infected by bacteria. It can be caused by broken teeth, cavities, fractured teeth roots, and many more [12]. Enamel corrosion occurs on the outer layer of our teeth. Enamel is the substance that covers and protects our teeth from physical and chemical damage. The main factors of enamel corrosion are the consumption of sugary products, acidic products, medications, and many more [13].

C. Types of Oral Treatments

The common oral treatments that can be seen performed for the oral problems above are bridges, fillings, root canal treatment, braces, tooth extraction, and teeth whitening. Bridges are treatment that acts as a replacement for an empty tooth by supporting itself using the surrounding teeth. Bridges are often made using porcelain and precious metals, and are installed in the mouth [14].

Filling are treatments that are used to repair the teeth caused by cavities. Most common fillings are made with a composite resin, but it can also be made from a mixture of metals [14]. Root canal treatment, as the name suggests, is the treatment on the root canal that are infected by bacteria. It is done by removing the infection found in the root canal and is filled with filling to stop it from getting infected again [14]. Braces are performed to straighten and reposition the teeth to promote better looking teeth appearance and operation. Traditional looking braces are made of metal and plastic, with newer invisible braces being made from clear plastic [14].

Tooth extractions are treatments that remove the teeth. The factors of having the teeth removed can be due to the teeth being affected by cavities, root infection, damage, and many more [14]. Teeth whitening is a treatment to make your teeth more appealing by bleaching your teeth to make them become whiter and brighter [14].

D. Existing Systems

From the study, we have chosen three existing systems that are advertised in scheduling appointments for dental clinics. The system chosen are MyDentalClinic, Picktime, and Timely.

Figure 1 shows the dashboard page of the MyDentalClinic application. MyDentalClinic is an application that helps the clinic to keep track of their patient's dental information [15]. The application consists of features such as add patient, add appointment, view upcoming appointments, and etc. The pros of the application are its intuitive design, making it easy to use. Next, the patients are allowed to register a profile online, this negates the use of paper for patient registration. Finally, there is a built-in dental chart for the dentist to use. As for the con, the patients are not allowed to book appointment. The appointments can only be made by the dental clinic.

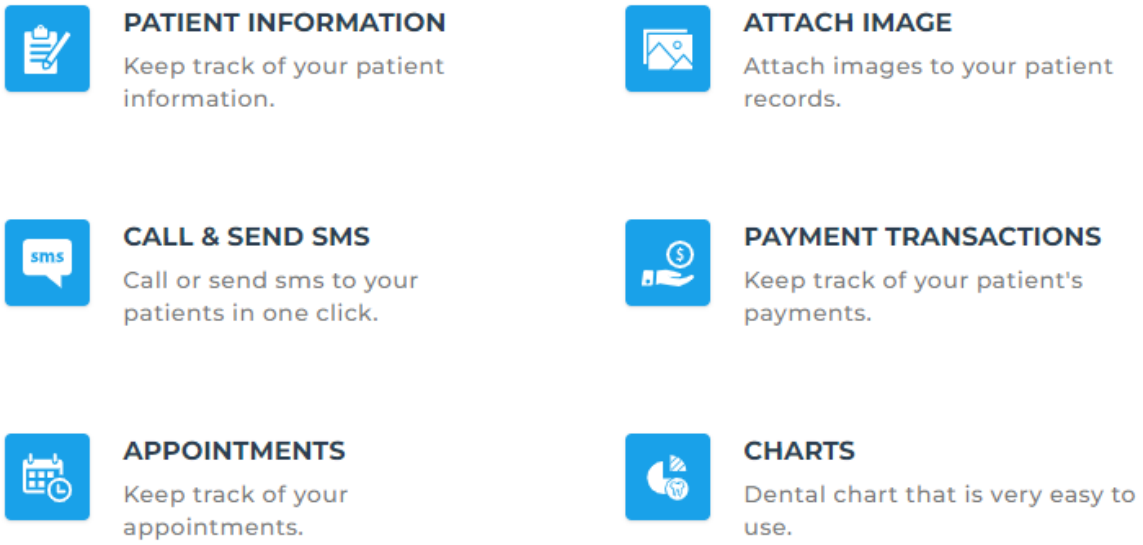

Figure 1. MyDentalClinic dashboard

Figure 2 shows the dashboard page of the Picktime application. Picktime is an online appointment scheduling application that allows businesses to perform appointment scheduling [16]. The application consists of features such as adding appointments, add customers, view upcoming appointments, perform payment, and many more. The pros of the application are that it can be customized to suit for different types of businesses. Moreover, it is able to generate an appointment booking link and share to customer. Finally, it can generate and view financial reports and expenses. As for the cons, the application does not give the customer access to past appointment details. Next, the application does not have the ability for the customer to perform changes to their appointment.

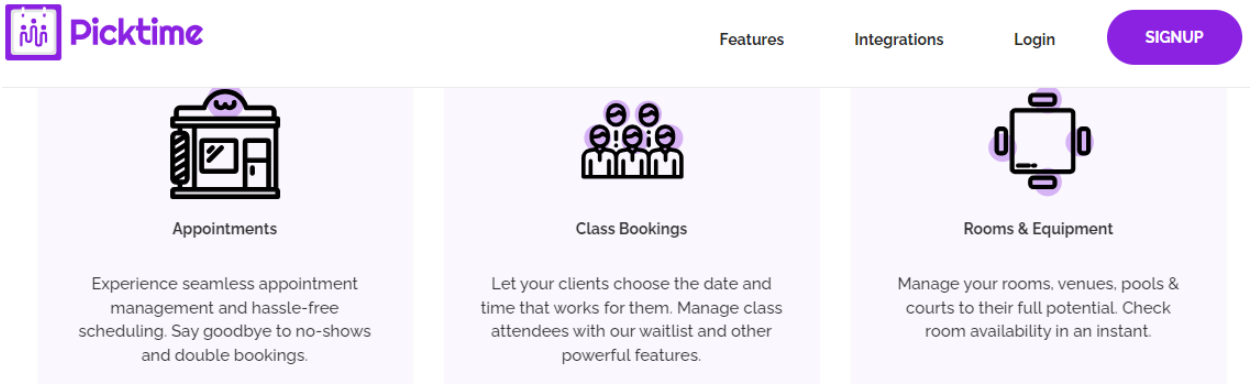

Figure 2. Picktime dashboard

Figure 3 shows the calendar page of the Timely application used by Drs. Wong & Partners Dental Surgeon (Subang Perdana Branch). Timely is a business management software that helps businesses to manage their business [17]. It is a type of appointment booking software that performs appointments scheduling for customers, with business minded features such as sending of marketing emails and checking sales and revenue. The pros of the application are it being able to send marketing messages to customers, and view their expenses and revenue earned. As for the cons, firstly, the patient's profiles only able to be registered in the clinic at the receptionist counter. Next, if a patient wants to make changes to their appointment, they will require to contact the clinic to make the request. Furthermore, the patient does not have access to using the application, which also translates to them being not able view their appointments, treatments performed, and dental records.

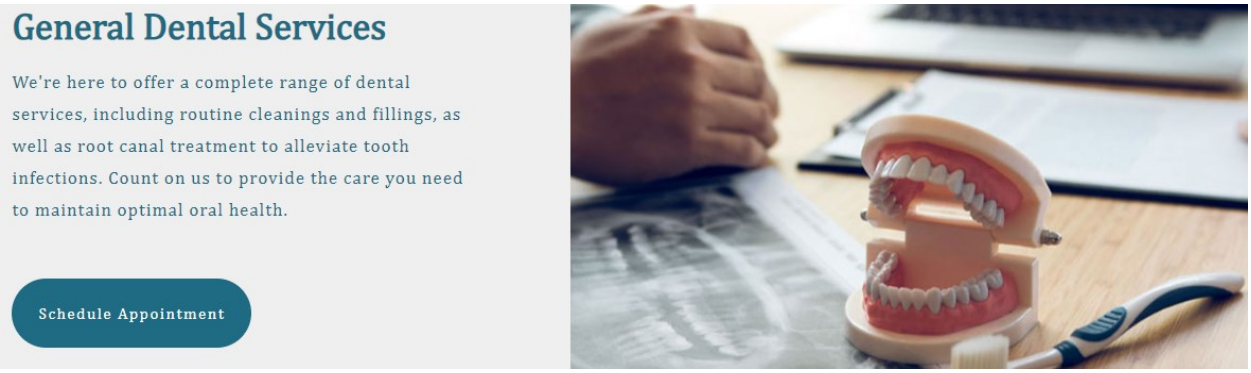

Figure 3. Schedule Appointment from Drs. Wong & Partners Dental Surgeon (Subang Perdana Branch)

E. Comparing System with Existing System

Table 1 shows the comparisons between the three existing systems of MyDentalClinic, Picktime, Timely, and our proposed system. Our proposed system is aimed to streamline dental clinic management for effective digitisation productivity and usability especially in viewing treatment history, adding treatment details, and digitising the mechanism where the dentist to give comments to patient. By digitising treatment updates and synchronization, the web application can provide accurate and up-to-date information about appointment availability, reducing the likelihood of dental treatment mismatches. The software requirement engineering process will also involve conducting thorough testing and quality assurance measures to ensure the reliability, security, and scalability of the web application, providing a robust solution for dental clinic management needs.

III. RESEARCH METHODOLOGY

Figure 4 shows the use case diagram for the Dental Clinic Management System (DCMS). The DCMS application is built for patients and dental staff usage in a dental clinic. The dental staff includes a dentist and administrator or receptionist. Before using the system, they would be required to register an account first. After completing the registration process, they would then be able to login into the system and perform various functions such as create appointments, view appointments, manage their appointments, edit and delete appointments.

Furthermore, they could also view their past appointments and treatment history, alongside the invoices from their past appointments. As for the dentist, they can login into the system, view upcoming appointments, view past appointments and the treatments performed. Finally, for the administrator or receptionist, they are able to login to the system, manage patient's appointments, such as creating new appointments, editing existing appointments and cancelling appointments. They also can view the patient's appointment history and treatment history, and finally, generate invoices for patient's appointment and view them.

Table 1. Comparison between existing system and proposed system

Functions	Existing System			Proposed System
	MyDentalClinic	Picktime	Timely	
Patient Account	Y	N	N	Y
Login				
Patient	N	N	N	Y
Staff	Y	Y	Y	Y
Create Appointment				
Patient	N	N	N	Y
Dentist	Y	Y	N	N
Staff	-	Y	Y	Y
Edit Appointment				
Patient	N	N	N	Y
Dentist	Y	Y	N	N
Staff	-	Y	Y	Y
Cancel Appointment				
Patient	N	N	N	Y
Dentist	Y	Y	N	N
Staff	-	Y	Y	Y
View Treatment History				
Patient	N	N	N	Y
Dentist	Y	Y	N	Y
Staff	-	Y	Y	Y
Add Treatment Details	Y	N	N	Y
Dentist give comments to patient	N	N	N	Y

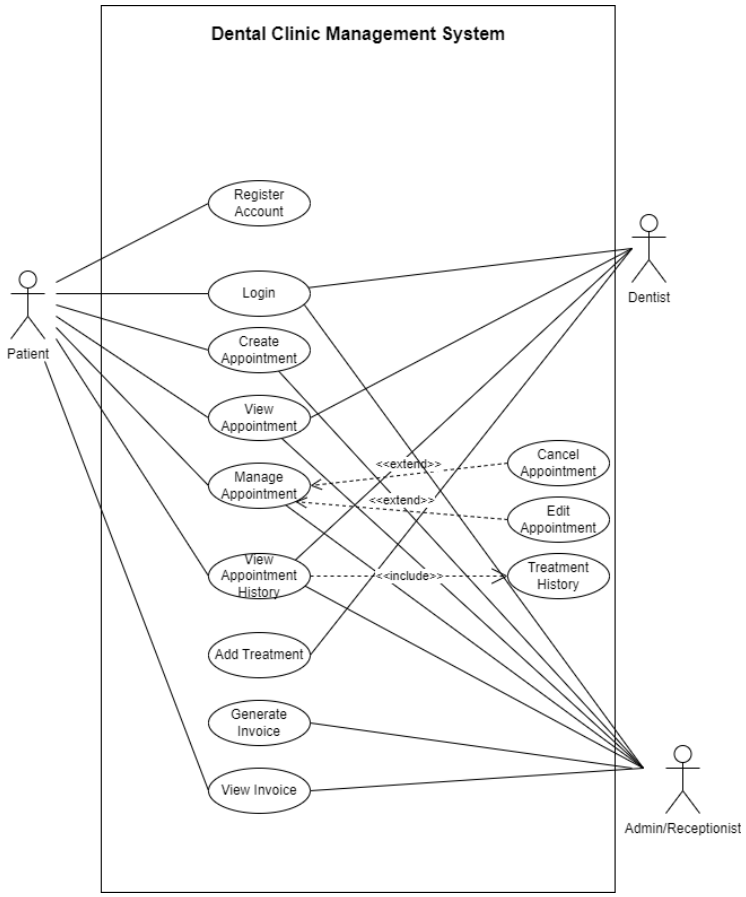

Figure 4. Use case diagram of Dental Clinic Management System (DCMS)

The software stack through Visual Studio Code, React, CSS, TypeScript, and Firebase are typically including various components, such as front-end frameworks, styling languages, programming languages, and back-end technologies. Front end frameworks like React play a pivotal role in structuring and managing user interfaces, allowing developers to create reusable components and handle application state efficiently. The framework is produced by Facebook and are in the trend for development framework [18].

Styling languages like CSS provide the means to define the visual appearance of these interfaces, enabling customization and responsive design. Programming languages like TypeScript bring strong typing and enhanced tooling to the development process, ensuring code correctness and scalability. It is also a superset of JavaScript, mainly extends JavaScript with type annotations makes it easy to debug problems [19].

On the back end, technologies like Firebase provide database storage and management capabilities, facilitating efficient data handling and real-time synchronization. Firebase is a Google platform that simplifies the creation, maintenance, and scaling of projects for developers [20]. Together, these components form a comprehensive technology stack [21][22], which empowers developers to create sophisticated web applications with seamless user experiences [23][24][25].

Figure 5 represents the context diagram for Dental Clinic Management System (DCMS). Context diagrams, also known as Data Flow Diagram (Level 0), are a high-level view of a system that maps out the interactions of different entities with the system. Firstly, for the patient's inputs, there would be account registration, login, create appointments, edit appointments, cancel appointments, and view invoices. For the outputs, the patient would receive results of their account registration, login results, appointment details, history of their appointments and treatments.

Moreover, for the dentist inputs, there would be login of account, adding treatment, and giving comments for the treatments. As for the outputs to the dentist, the system would send the login results, their patient's appointment details, past appointments, and treatments history. Next, for the administrator or receptionist inputs, they would

perform account login, help patients to create appointments, edit appointments and cancel appointments. Invoices details are also entered for the patient's invoice generation. For the outputs to the administrator or receptionist, the system would send the login results, the patient's upcoming appointments and past appointments details.

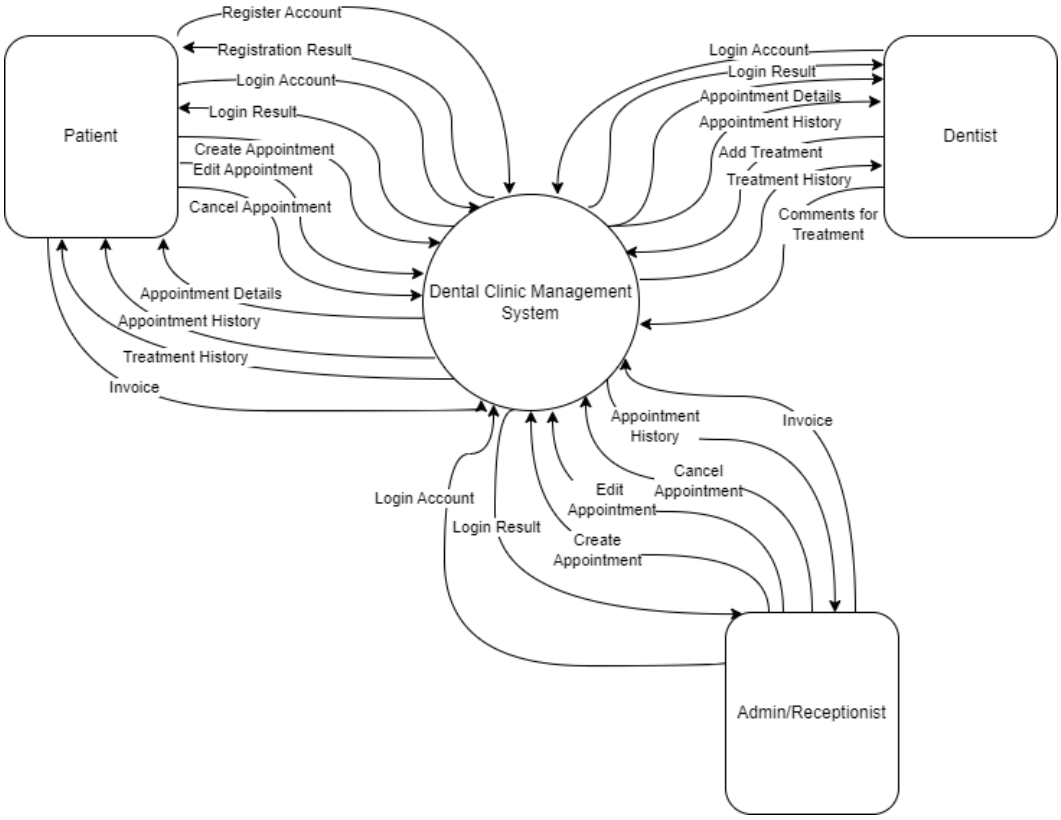

Figure 5. Context diagram of Dental Clinic Management System (DCMS)

IV. RESULTS AND DISCUSSIONS

A. Interface Design

Figure 6 shows the patient's home dashboard of the Dental Clinic Management System (DCMS). For the dashboard, the layout and designed are sectioned into two panels. On the left panel, it would show a welcome patient name message, with some option menus below it, such as book an appointment, appointment, past appointments, treatments, and invoices.

As the options menu name suggested, selecting book an appointment would allow the patient to book a new appointment with the dentist, appointments would display upcoming appointments to the patients, past appointments would display previous appointments, treatments would show the treatments performed, and finally, invoices would display previous invoices for viewing. Moreover, just below all those options, there is a dashboard and log out option for the patient to go to the dashboard or log out of the system. On the right panel of the screen, it will display upcoming appointments, past appointments, treatments, and invoices to the patient immediately of a screen.

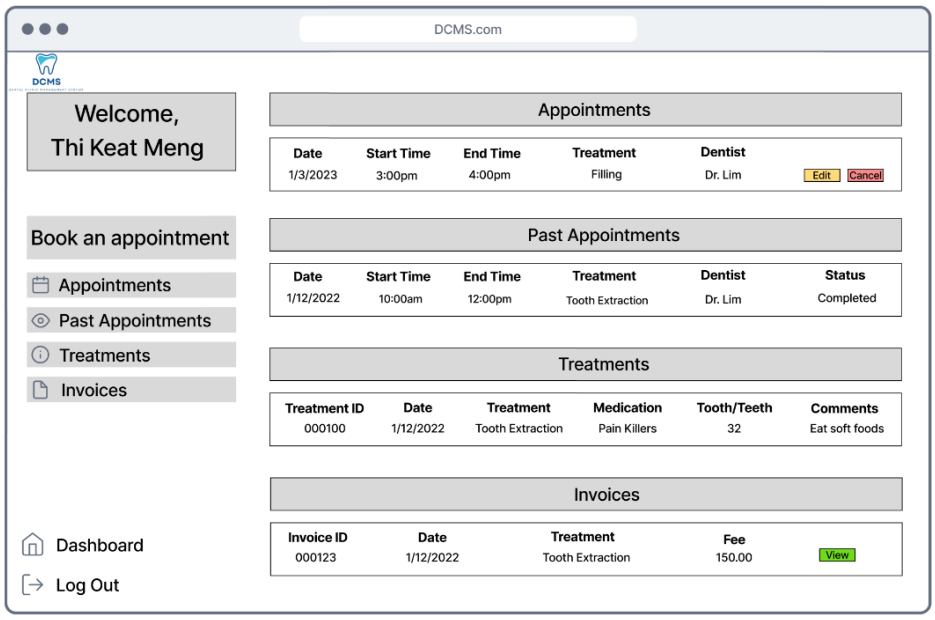

Figure 6. Patient home dashboard of Dental Clinic Management System (DCMS)

Figure 7 shows the dentist's home dashboard of the Dental Clinic Management System (DCMS). Just like patient's, the layout and design of the dentist's dashboard are sectioned into two panels. The left panel would show a welcome dentist name message, with some option menus below it, such as upcoming appointment, past appointments history, patient treatment records, and apply treatment. As the options menu name suggest, selecting upcoming appointments would display upcoming patient's appointments assigned to the dentist, past appointments would display previous appointments, patient treatment records would show the treatments the patients performed, and finally, apply treatments would allow the dentist to apply treatment. On the right panel of the screen, it will display upcoming appointments, past appointments history, and patient treatment records to the dentist immediately of a screen.

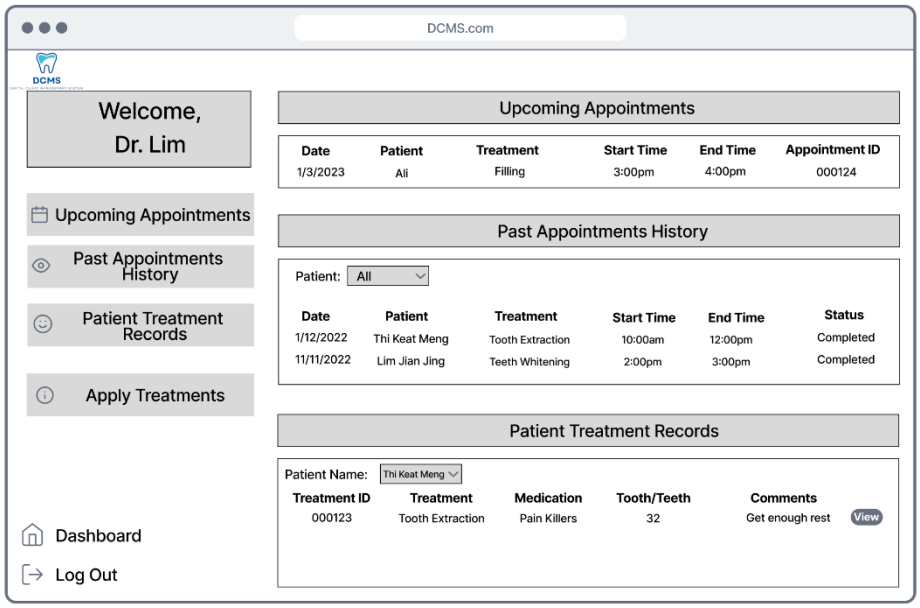

Figure 7. Dentist home dashboard of Dental Clinic Management System (DCMS)

Figure 8 shows the administrator's or receptionist's home dashboard of the Dental Clinic Management System (DCMS). Just like patient's and dentist's, the layout and design of the dentist's dashboard are sectioned into two panels. The left panel would show a welcome administrator's or receptionist's name message, with some option menus below it, such as book an appointment, upcoming appointment, patient records, and invoices. As the options menu name suggest, selecting book an appointment would book a new appointment for the patient, upcoming appointments would display upcoming patient appointments, patient records would allow the administrator or receptionist to select which patient profile to search for, and finally, invoices would allow the administrator or receptionist to apply and view invoices. On the right panel of the screen, it will display upcoming appointments, and patient records.

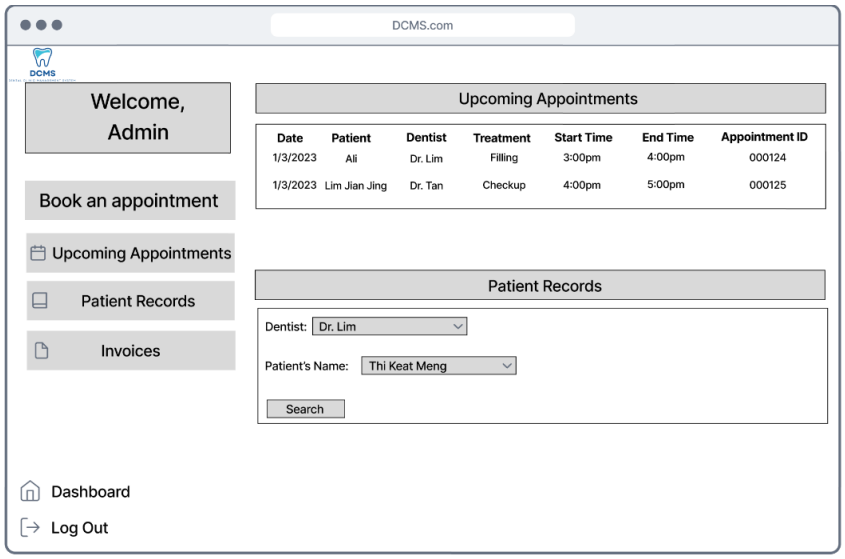

Figure 8. Admin or receptionist home dashboard of Dental Clinic Management System (DCMS)

Figure 9 shows the patient's booking an appointment screen of the Dental Clinic Management System (DCMS). In this screen, the patient would be required to select the date of appointment, treatment types, dentist for the appointment, and finally time of desired treatment. After done selecting the required information, clicking the book appointment button will complete the appointment booking process.

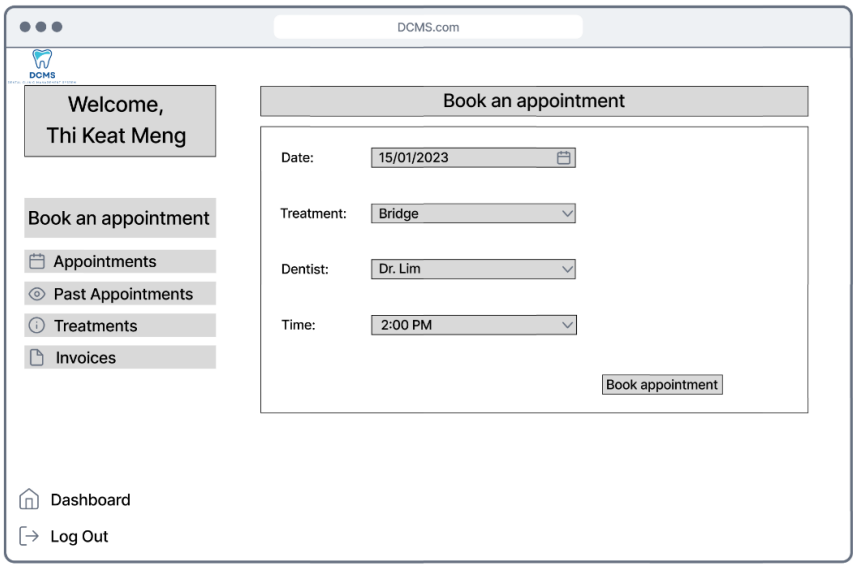

Figure 9. Patient creates appointment screen of the Dental Clinic Management System (DCMS)

Figure 10 shows the administrator's or receptionist's booking an appointment screen of the Dental Clinic Management System (DCMS). In this screen, the administrator or receptionist would be required to select the patient, the date of appointment, treatment types, dentist for the appointment, and finally time of desired treatment. After done selecting the required information, clicking the book appointment button will complete the appointment booking process.

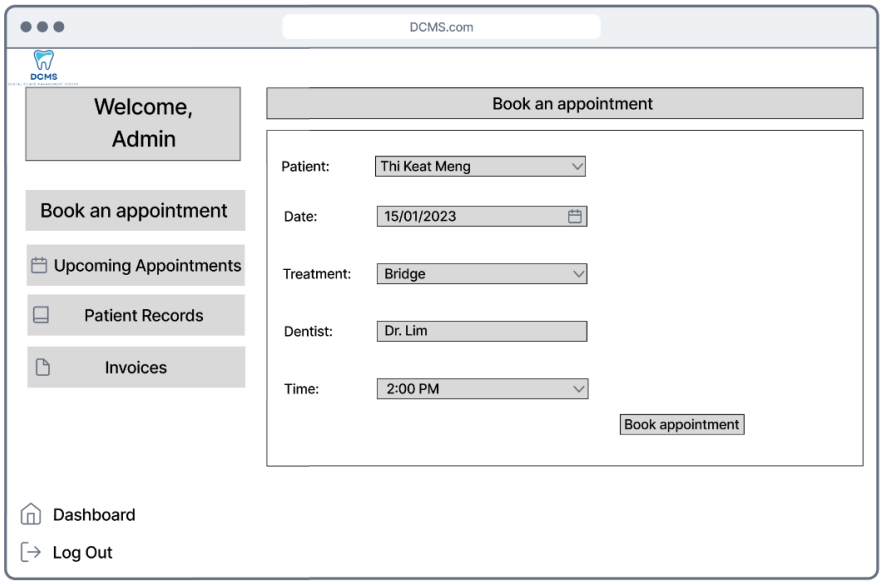

Figure 10. Administrator or receptionist create appointment screen of the Dental Clinic Management System (DCMS)

Figure 11 shows the patient's edit appointment screen of the Dental Clinic Management System (DCMS). In this screen, the patient would require selecting a new date or time should they desire to edit their current appointment time. The system will also display the patient's current appointment schedule for their reference. Once they have decided the date and time, selecting the update button would complete their appointment editing and update the appointment.

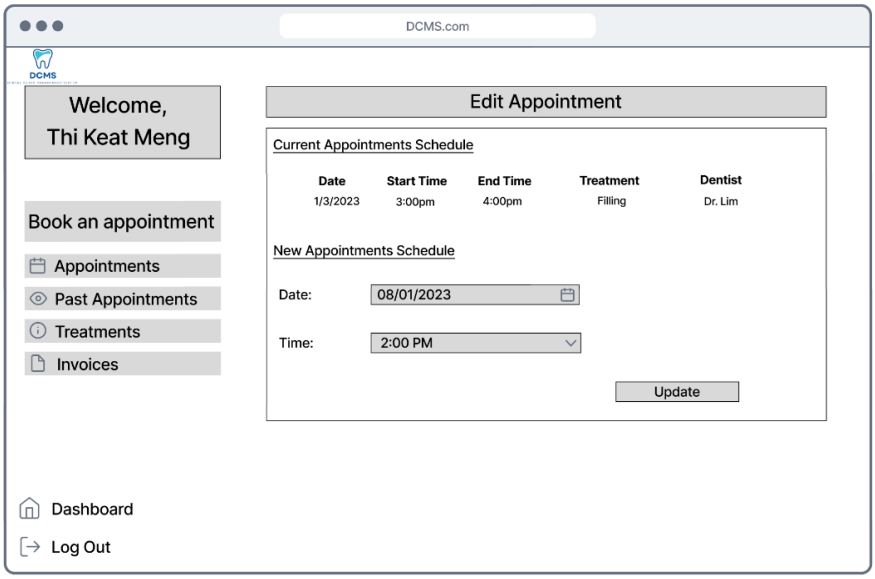

Figure 11. Patient edits appointment screen of the Dental Clinic Management System (DCMS)

Figure 12 shows the dentist's apply treatment screen of the Dental Clinic Management System (DCMS). In this screen, a dental chart, alongside teeth condition and legend will be displayed. The dentist would select the patient's name and the appointment ID for the treatment. The dentist would then require filling in the patient's dental details

such as their teeth conditions, the treatments performed on which tooth or teeth, given medication and comments of the treatment for the patient's viewing. Once the dentist has finished filling up, clicking the submit button would complete the adding of treatment.

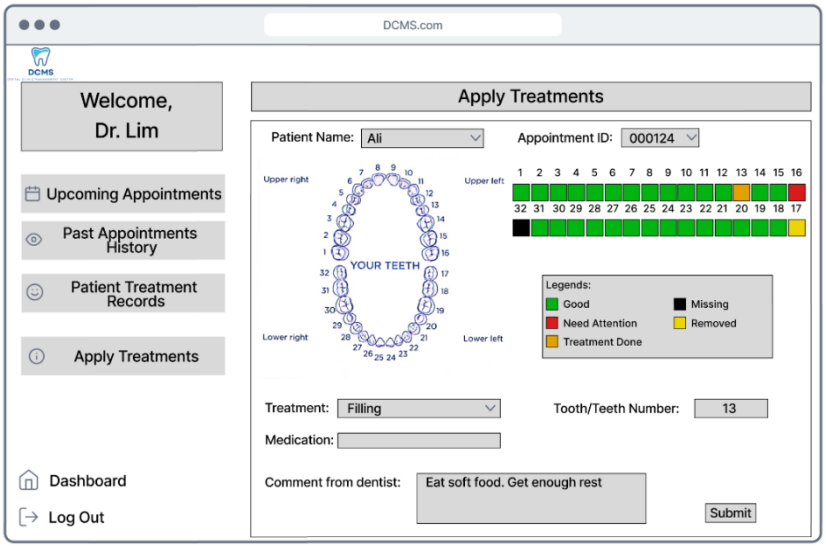

Figure 12. Dentist applies treatment screen of the Dental Clinic Management System (DCMS)

Figure 13 shows the patient's view treatment screen of the Dental Clinic Management System (DCMS). In this screen, a dental chart, alongside teeth condition and legend will be displayed. The patient can view their teeth conditions, the treatment performed on which tooth or teeth, given medication and comments by the dentist.

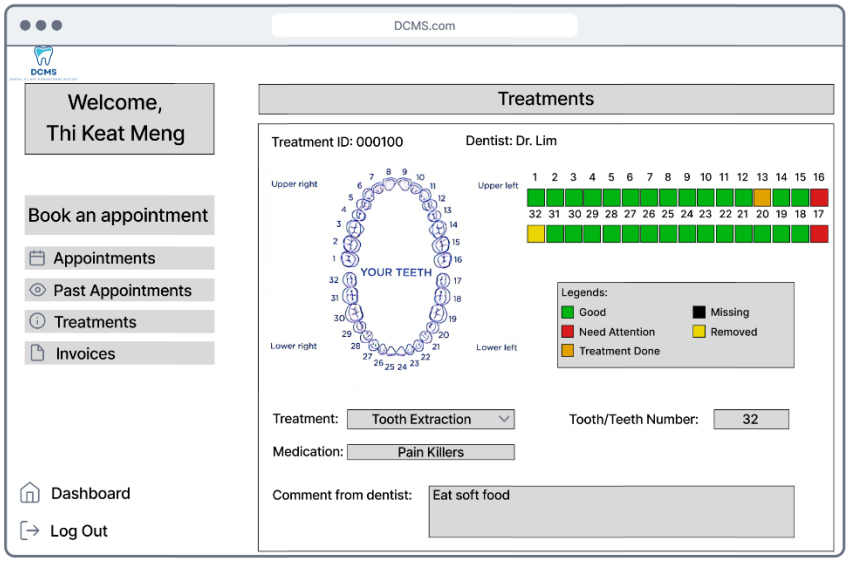

Figure 13. Patient view treatment screen of the Dental Clinic Management System (DCMS)

Figure 14 shows the administrator's or receptionist's view and create patient invoice screen of the Dental Clinic Management System (DCMS). In this screen, the previous invoices of the selected patient would be displayed. To create an invoice, the administrator or receptionist would select the date of appointment, the appointment ID, and fill in the fee for the appointment and treatment. Once done, clicking the create button will create the invoice for the patient.

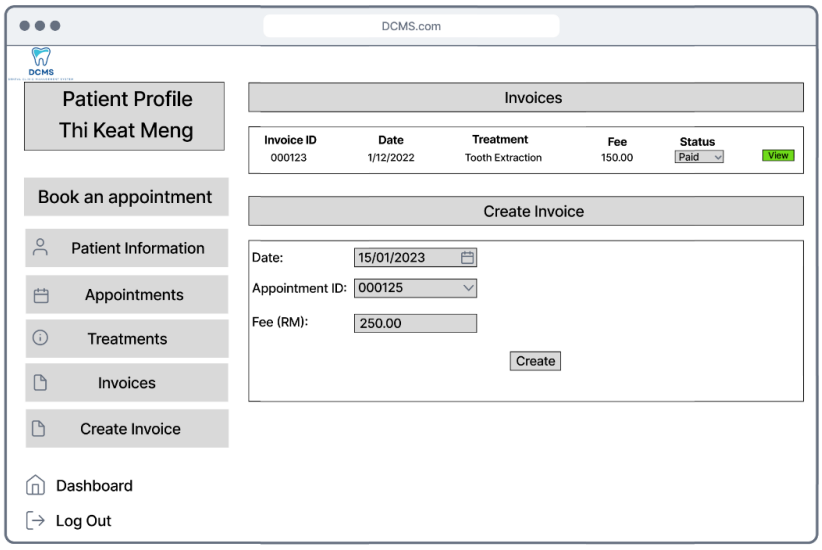

Figure 14. Administrator or receptionist view and create patient invoice screen of the Dental Clinic Management System (DCMS)

Figure 15 shows the patient's view invoice details screen for the Dental Clinic Management System (DCMS). In this screen, it will display the date, time, dentist assigned, appointment ID, treatment ID, patient name, treatment type, tooth or teeth operated, medication given, and the fee of the selected appointment.

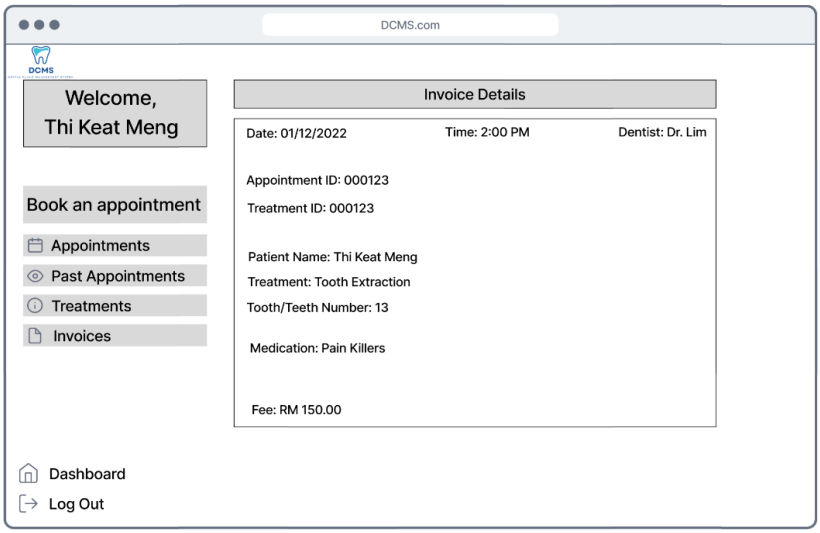

Figure 15. Patient view invoice details screen of the Dental Clinic Management System (DCMS)

B. Code Implementation

A high-level pseudocode is illustrated in Figure 16 to further support the feasible architecture framework and flow mechanism of the Dental Clinic Management System (DCMS). The list of user interfaces (Patient, Dentist, Administrator) and their attributes and methods are defined. Each interface is listed with the types of properties required.

In addition, we use the "useState" hook to handle the information data retrieved from the App collection and add each value to the set of arrays, ready to be added into Firebase database. Each state variables are initialized with different types of interfaces that can hold objects of its specified type.

Finally in the main program loop, the main application logic is first evaluated to create a continuous loop for user interaction and will continue to run until the program explicitly breaks out of it. Entering the loop, the function "displayMenuOptions()" allows the user to choose their role, either as Patient, Dentist, Administrator, or to Exit Program. Upon selecting, the "geUserChoice()" function evaluates the input and determines the corresponding functions based off the user's selection. Each user selections will be authenticated by the stated function "authenticateUser()". If the authentication is successful, the specific menu functions ("patientMenu()", "dentistMenu()", "administratorMenu()") will be called from the corresponding user selected.

After finalizing the type of user and methods to call, the program proceeds to render the required UI (User Interface) components from the "App" interface to interact with the user.

User Interfaces (Patient, Dentist, Administrator)

```
// User interface
interface User {
        id: string;
        name: string;
        contactInfo: string;
}
// Patient interface extends User
interface Patient extends User {
        medicalHistory: string[];
        appointments: Appointment[];
        viewMedicalHistory: () => void;
        scheduleAppointment: () => void;
        viewAppointmens: () => void;
        receiveFeedback: () => void;
}
// Dentist interface extends User
interface Dentist extends User {
        specialization: string;
        appointments: Appointment[];
        viewAppointments: () => void;
        performTreatment: () => void;
        provideFeedback: () => void;
}
// Administrator interface extends User
interface Administrator extends User {
        manageAppointments: () => void;
        viewPatientRecords: () => void;
        createInvoice: () => void;
}
```

Use Case interfaces (Appointment, Invoice)

```
// Define Appointment interface to manage appointments
interface Appointment {
        appointmentId: string;
        patientId: string;
        dentistId: string;
        appointmentDatetime: string;
        treatmentDetails: string;
}
// Define Invoice interface to manage billing
interface Invoice {
        invoiceId: string;
        patientId: string;
        totalAmount: number;
```

```
        paymentStatus: string;
}
```

Data Structures

```
const App: React.FC = () => {
        // State variables to store data
        const [patients, setPatients] = useState<Patient[]>([]);
        const [dentists, setDentists] = useState<Dentist[]>([]);
        const [administrators, setAdministrators] = useState<Administrator[]>([]);
        const [appointments, setAppointments] = useState<Appointment[]>([]);
        const [invoices, setInvoices] = useState<Invoice[]>([]);
}
```

Main Program Loop

```
const App: React.FC = () => {
        while (true) {
            displayMenuOptions();
            const userChoice = getUserChoice();
            if (userChoice === "Patient") {
                const patient = authenticatePatient();
                if (patient) {
                    patientMenu(patient);
                }
            }else if (userChoice === "Dentist") {
                const dentist = authenticateDentist();
                if (dentist) {
                    dentistMenu(dentist);
                }
            }else if (userChoice === "Administrator") {
                const administrator = authenticateAdministrator();
                if (administrator) {
                    administratorMenu(administrator);
                }
            }else if (userChoice === "Exit") {
                exitProgram();
                break;
            }
            // returns UI components
            return (
                <div className="App">
                    <...>
                </div>)
};
export default App;
```

Figure 16. High-level pseudocode of the Dental Clinic Management System (DCMS)

V. CONCLUSION

In conclusion, the use of a web-based Dental Clinic Management System (DCMS) would bring plenty of convenience and improvements to dental clinics. Patients and dental clinic personnel are able to profit from improved productivity, usability, and accessibility by adopting digitalization and shifting away from traditional paper based dental charts to digital based system. This system addresses the disadvantages and constraints of traditional paper based dental records, such that the patient's information, such as teeth condition information, treatment records, and appointment details are all recorded directly into the system, rather than onto paper, which reduces the likelihood of the patient's dental information getting lost. Furthermore, due to the nature of this system being web-based, as long as the patient has internet access, they are able to register themselves into the system and check their dental information and manage appointments. This would also result in better flexibility as they would no longer be required to contact the dental clinic personnels to manage their appointments. Additionally, dental

clinic personnels would also benefit from workflow improvements, with one of the features allowing them to search and access the patient's dental information directly from the system, rather than having to go through their records storage and find them.

To sum up, the usage of a Dental Clinic Management System (DCMS) would help digitalize a dental clinic, which include performing the system acceptance or functional test in the future work. With this, this system can offer a better, accessible, and flexible way of handling patient data and information, and providing better workflow in a dental clinic workspace.

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AUTHOR CONTRIBUTIONS

Sin-Ban Ho: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Resources, Supervision, Writing – Original Draft Preparation;
En-Yu Chew: Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – Original Draft Preparation;
Chuie-Hong Tan: Project Administration, Supervision, Writing – Review & Editing

CONFLICT OF INTERESTS

No conflict of interests were disclosed.

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