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Lightweight Full-stack Web-based Solution for An Educational Organization

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***Abstract*— This paper discusses the web application of the Zonal Education Office, Katugastota and the development and deployment process. The problem statement is discussed using two main parts. They are organizational problems and general problems. The organizational problems discuss the current problems in the organization which needed to be overcome using a web application. The general problems describe the problems that the majority of the organizational web applications were facing. Considering the problem domain, the main aims and objectives were identified. Consequently, the proposed web application provides a lightweight, customizable, usable, cost-effective and secure web experience to the client by ensuring improved decision supportability, productivity and user experience for the organizational stakeholders. The lightweight approach benefited to use of a small amount of disk space for greater productivity, and reduce the loading time of the overall web application. LAMP stack was used to develop this web application. Furthermore, this web application used a few SaaS (Software As a Service). This web application was tested over unit testing, integration testing, system testing and user acceptance testing. The evaluation of the web application was done by design review, questionnaire and comparing similar systems. Since the client was satisfied with the current functionality of the final web application, the web application was deployed.**

I. INTRODUCTION

This paper discusses the process of system requirement specification, implementation, testing, evaluation, project management and deployment of the lightweight, cost-efficient web solution for an educational organization in Sri Lanka called Zonal Education Office, Katugastota. Moreover, this development project is a web-based solution for the organization that addresses the current organizational needs that can be capable enough to build with a web-based approach.

The problem statement was discovered by using peer discussions, a survey/ a questionnaire and an interview session. Therefore, the problem statement is discussed using two main parts. They are organizational problems and general problems. Furthermore, the organizational problems discuss the current problems in the organization which needed to be overcome using a web application. The general problems describe the problems that the majority of the organizational web applications were facing. The organizational problems were, distributing paper-based documentation, the unnecessary number of client visits to the organization's premises since the COVID-19 pandemic situation, unnecessary time wastage of the organizational clients, and no experts to manage a complex web application. The general problems were, not frequently updating the content of the web application, the cost of maintaining a web application, and lack of provision allocation.

The adoption of web-based solutions in this organization will result in the simplification of organizational procedures. Improvements in organizational processes can result in increased staff productivity and cheaper expenses. Moreover, Web-based solutions make providing real-time information more convenient, this may increase the quality and speed of decision-making. Moreover, the web-based system may be accessed from any place since it is hosted on the internet [1].

The project considered only the organizational requirements which are capable enough to build the web-based application. The proposed web application collectively has two sides called the web application of 'Admin panel' and the 'Client side's web application'. Furthermore, the client side's web application belongs to the viewers of the web application and the operations in the 'Admin Panel' belong to the administrator and moderators in the system.

By considering the problem domain of this development project, the main aims and objectives were stated. The main aims and objectives of the web application were to build a lightweight web solution, improve customizability, reduce cost, improve decision supportability, improve productivity & connectivity, improve web security, and provide organizational content to the users. Therefore, this web application provides a lightweight, customizable, usable, cost-effective and secure web experience to the client by ensuring improved decision supportability, productivity and user experience for the organizational stakeholders as mentioned in the aims and objectives.

Moreover, this project provides a number of deliverables to the organization as well. They are exhibiting organizational analytics and organizational information, collecting user feedback/inquiries, providing downloadable resources, reducing the maintenance cost of the web application, providing web-based profiles to other sub-organizations (schools), providing a positive user experience (UX), providing security to the organizational data in the webspace, and reducing the complexity of the roles of administrator & moderator of the web application.

This section described a brief introduction to the implemented web application. The next section describes the literature that was considered to build this web application. After that, requirement gathering techniques used, functional requirements, non-functional requirements, hardware requirements, and software requirements are briefly described in the requirement specification. Moreover, the details of the implemented system are discussed in the methodology section. Future changes and additions are described in the future works section. Finally, the results of the evaluation and testing is briefly described in the conclusion.

II. Literature Review

There are lots of organizational websites on the internet. Mainly, those websites can be divided into two major types based on their characteristics. They are static websites and dynamic websites. Static Web pages are fairly simple. The minority of the dynamic websites use open-source/ proprietary CMSs, and the majority of them are special purpose full-stack web applications (Non-CMS) [1].

Moreover, these identified web solutions use SEO (Search Engine Optimization) to improve the appearance and positioning of web pages in organic search results [2].

As pointed out in [3], the maintenance cost is different based on web site category. Therefore, domain registration cost, website hosting cost, content costs, general update cost, design update cost, tech support, security cost, tracking and analytics cost, and marketing cost were considered as different maintenance costs that affect different kinds of web applications.

As pointed out in [4] and [5], According to the statistics of Internet users in Sri Lanka, in January 2021, there were 10.90 million internet users. However, between 2020 and 2021, the number of internet users in Sri Lanka grew by 800 thousand (+7.9%). Therefore, Sri Lanka had a 50.8 per cent internet penetration rate in January 2021. In 2020, internet penetration in Sri Lanka had 47 per cent of the total population. According to an online user analysis in 2021 [5] , it has a +7.9% internet user growth from the total population of 21.46 million. Moreover, by considering population by age group 71.7% of the total population (21.46 million) are population aged 18 and above.

A few suitable organizational web applications were considered in this study. They were organizational websites of the Ministry of Education - Sri Lanka, Ministry of Education (Higher Education) - Sri Lanka, The Information and Communication Technology Agency (ICTA) – Sri Lanka, Department of Irrigation, Sri Lanka and Zonal Education Office, Hingurakgoda, Sri Lanka. Therefore, as pointed out in [6], [7], [8], and [9], the major features were compared in identified organizational web applications. The feature comparison is done by using responsive web design (RWD), search engine optimization (SEO), security enhancements, colour scheme and web design pattern over those 5 organizational web solutions in Sri Lanka. The comparison is shown in *Table I*.

TABLE I. Comparison of identified organizational web solutions in Sri Lanka

	Ministry of Education, Sri Lanka	**Department of Irrigation, Sri Lanka**	**Ministry of Higher Education, Sri Lanka**	**Information and Communication Technology Agency (ICTA) of Sri Lanka**	**Zonal Education office, Hingurakgoda, Sri Lanka**
Responsive Web Design (RWD)	Yes	No	Yes	Yes	Yes
Search Engine Optimization (SEO)	Enabled	Enabled	Enabled	Enabled	Enabled
Security Enhancements	HTTPS used	HTTPS used	HTTPS used	HTTPS and Google reCAPTCHA used	HTTPS used
Colour Scheme	Monochromatic colour scheme	Not used	Logo based colour scheme	Logo based colour scheme	Monochromatic colour scheme
Web design Pattern	Z-pattern layout, F-pattern layout, grid structure	F- pattern layout	Z-pattern layout, F-pattern	Grid Structure	Grid Structure

III. Requirement Specification

This section discusses the requirement gathering of the development project by using the requirement gathering techniques. After that, it briefly describes the functional and non-functional requirements which are gathered using requirement gathering techniques. Moreover, this section briefly describes the software requirements and the hardware requirements of the web application.

A. Requirement Gathering

The literature review was done as the secondary requirement gathering technique. The primary requirements-gathering techniques used for this development project were interviews, peer discussions (brainstorming sessions), prototyping, background readings and online questionnaires. Therefore, a requirement elicitation plan over the primary requirement-gathering techniques was created. The requirement elicitation plan is shown in *Table II.*

TABLE II. Requirement elicitation plan

Objective	Technique	Action taken	Time commitment
To understand the background of the Zonal Education Office, Katugastota, Sri Lanka and to gather initial requirements for the proposed web application	Background readings	The documentation of 'School Monitoring and Evaluation Program 2021' by Katugastota Educational Zone.	3 days
To identify the current problems of the organizational web applications in Sri Lanka.	Brainstorming sessions/ peer discussion.	4 of final year undergraduates among undergraduates in the Faculty of Computing and Technology, University of Kelaniya, Sri Lanka.	1 week
To identify the problem domain and gather initial requirements	Interview (via a WhatsApp Group Call)	Zonal Director, Katugastota Zonal Education (Mrs. Y.M.M.K. Yapa), In Service Advisor (ISA) in History (J.M.R.N. Jayasundara), In Service Advisor (ISA) in Information and Communication Technology (K. Dissanayake)	1 hour
To further identify the problem domain and prioritize the gathered requirements.	Questionnaire (using Google Forms)	40 employees among the Zonal Director Board and the Zonal ISAs (In-Service Advisers) in Zonal Education Office, Katugastota, Sri Lanka	1 week
To get feedback on current development and gather more new requirements.	Prototype (Evolutionary)	Director of Information Communication Technology, Zonal Education Katugastota (Mrs D.U.D. Niroshini), Head of director in Planning Branch (Mr Ranjith Siriwardane)	1 and ½ hour

B. Functional Requirements

Functional requirements were derived by using the discovered findings from primary requirement gathering techniques (interviews, peer discussions/ brainstorming sessions, background readings, online questionnaires) and the secondary requirement gathering technique (literature review). By considering the MoSCoW method, these requirements were prioritized [10]. The summarized functional requirements are shown in *Table III.*

TABLE III. FUNCTIONAL REQUIREMENTS

Administrator Requirements	Moderator Requirements	Visitor Requirements
• The administrator shall be able to log in and log out of the system. • The administrator shall be able to manage (view, create, update, remove, and provide permissions) moderator accounts. • The administrator shall be able to change administrator credentials (username, password, email). • The administrator shall be able to manage (view, create, update, remove) web content over the web application.	• Moderators shall be able to log in and log out from the system if access is granted by the system administrator. • The moderator shall be able to manage (view, create, update, remove) web content over the web application if the access permissions are granted by the system administrator.	• The administrator shall be able to view web contents over the web application.

C. Non-functional Requirements

As pointed out in [11], 10 non-functional requirements were defined according to IEEE standard 1233, 1998. They are performance, maintainability, reliability, security, availability, training, documentation, policy and regulatory, globalization, and privacy.

D. Software Requirements

The software requirements of the web application are shown in *Table IV.*

TABLE IV. SOFTWARE REQUIREMENTS

PHP Version	Version < 7
PHP Extensions	PHP Mailer
Dependency manager	Composer (version 2.0.12 or higher)
Administration tool	phpMyAdmin with MySQL database.
Operating system (OS)	Windows 7 or higher (32bit or 64bit)/ Linux (32bit or 64bit)
Webserver	XAMPP webserver
Web Browser	Google Chrome, Firefox, Opera Mini, Brave, Microsoft Edge
Connectivity	Internet connection

E. Hardware Requirements

The hardware requirements of the web application are shown in *Table V.*

TABLE V. HARDWARE REQUIREMENTS

	Minimum Requirement	Recommended Requirement
CPU (Central Processing Unit)/ Processor	1GHz	2GHz or more
Memory (RAM - Random Access Memory)	2GB	4GB or more
Storage	HDD (Hard Disk Drive) with 5 GB storage capacity.	SSD (Solid State Drive) with 20GB storage capacity or more.
Internet connectivity device	Modem/ Router/ Dongle	Modem/ Router/ Dongle
Compatible Device(s.)	Desktop PC/ Laptop/ Smartphone/ Tablet	Desktop PC/ Laptop/ Smartphone/ Tablet

IV. METHODOLOGY

In this section, the implementation and deployment approach will be briefly described.

As pointed out in [12], today's software development projects do not rely on pure classic (waterfall model) or pure agile methods, because it is challenging to shift from one development methodology to another. Therefore, almost modern software development projects are using a hybrid approach called the 'Agile-waterfall Hybrid Model'. The major reason that to use the 'Agile-waterfall Hybrid' model is it shortens the design, analysis and planning. Furthermore, the project frames (budget and time of delivery) also can be defined.

Throughout the development of this web application, it used a 3-tier architecture with the server-side rendering architecture as shown in *Fig. 1*. Therefore, the server returns the data and displays an HTML page to the client since the HTML page is rendered on the server-side by using PHP. Moreover, data is stored on the server side by using the MySQL database [13].

A. Used Web Application Security Measures

As pointed out in [14]–[18], hackers and cyber-thrives are willing to access sensitive information without knowing the authorized users in the system. Therefore, secure software development best practices are needed. As software development best practices, security measures to DDos attacks (Distributed Denial-of-service attack), security measures to prevent XSS (Cross-site scripting) attacks, security measures to prevent SQLi (SQL Injection) attacks, storing passwords with encryption, one-time password and database error handling were used in this web application development.

B. Used Web-friendly Image Format

WebP is a lossy and lossless compression technology that uses a wide range of photographic, translucent, and graphical images on the internet [19].

Since the WebP format simply aims to provide smaller, better-looking pictures that can help to speed up the web application, the Administrator or a moderator allows to upload BMP, JPEG, GIF, and PNG images and those Images were converted to WebP format by using server-side PHP script and stored WebP image in the webserver. And WebP images can be directly uploaded to the web application as well. Furthermore, the image optimization process is also happening while uploading the image into the web application [19],[20].

C. Search Engine Optimization (SEO)

As pointed out in [21], Search Engine Optimization (SEO) is the method of getting web pages to rank higher in search engines like Google. Search is one of the most common methods for people to find content online. Therefore, ranking higher in search engines can contribute to an increase in traffic to a website. The results page of Google and other search engines frequently displays paid ads at the top of the page, followed by regular results, or what search marketers refer to as *organic search results*. To distinguish it from paid search traffic, SEO traffic is frequently referred to as *organic search traffic*. Since Google is currently the most popular search engine, Google search engine optimization was considered throughout the development of the web application. This web application used HTML codes for SEO, a site map for SEO, and clean URLs for SEO.

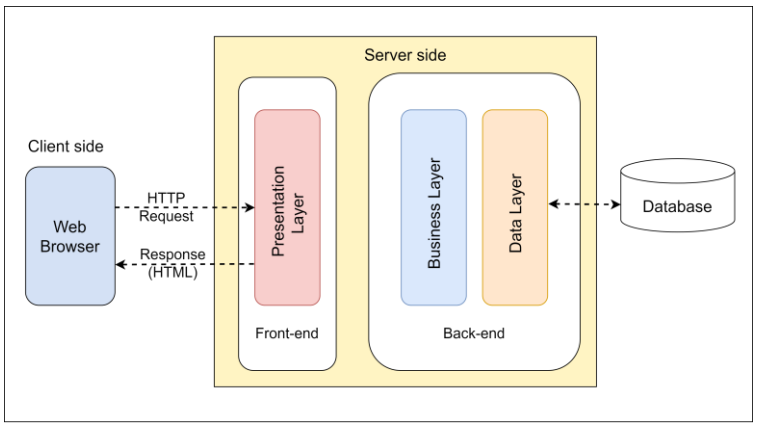

Fig. 1 High-Level Diagram

D. Special Features

As special features of this web application, the image compression algorithm, the OTP generation algorithm and the website maintenance mode were built into this web application without using any third-party service.

E. Database Implementation

As pointed out in [22], denormalization is the process of introducing redundant data to one or more tables. It eliminates costly joins in a relational database by using this technique. Denormalization is a method used in relational databases to improve read-oriented data retrieval performance.

F. Coding Best Practices

As pointed out in [23], to implement a web application, it needs to follow the best practices of coding. Therefore, this web application development process used reusable components, comments, code indentation, and dry approach as coding best practices.

G. UI (User Interface) Implementation

Several web design theories and principles were used to implement the web application. They were the Gestalt principle, F-pattern layout, Z-pattern layout, minimalism, colour selection and mobile responsive design [24], [25].

The web application of the Zonal Education Office, Katugastota used the main 3 colours of the logo of Central Province - Sri Lanka. Therefore, it used the logo-based colour selection technique [8]. The hexadecimal representations (HEX) of those colors are #661414, #ffd40, #fff. The colours are shown in *Fig. 2*. Furthermore, UI/UX design was used to design the buttons and #661414, #ffd400, and #fff were used as the primary colours of those buttons.

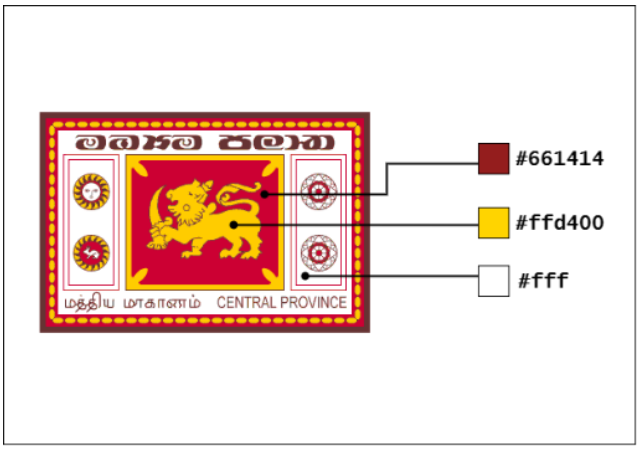

Fig. 2 The logo-based colour selection (Logo – Central Province, Sri Lanka)

H. Web application Deployment

The deployment was done by using a cPanel-based shared hosting plan and domain name purchased from Namecheap. GitHub version controlling was used to maintain track of the development work. Therefore, the final look after the deployment of the web application is shown by using a UML deployment diagram in *Fig. 3*.

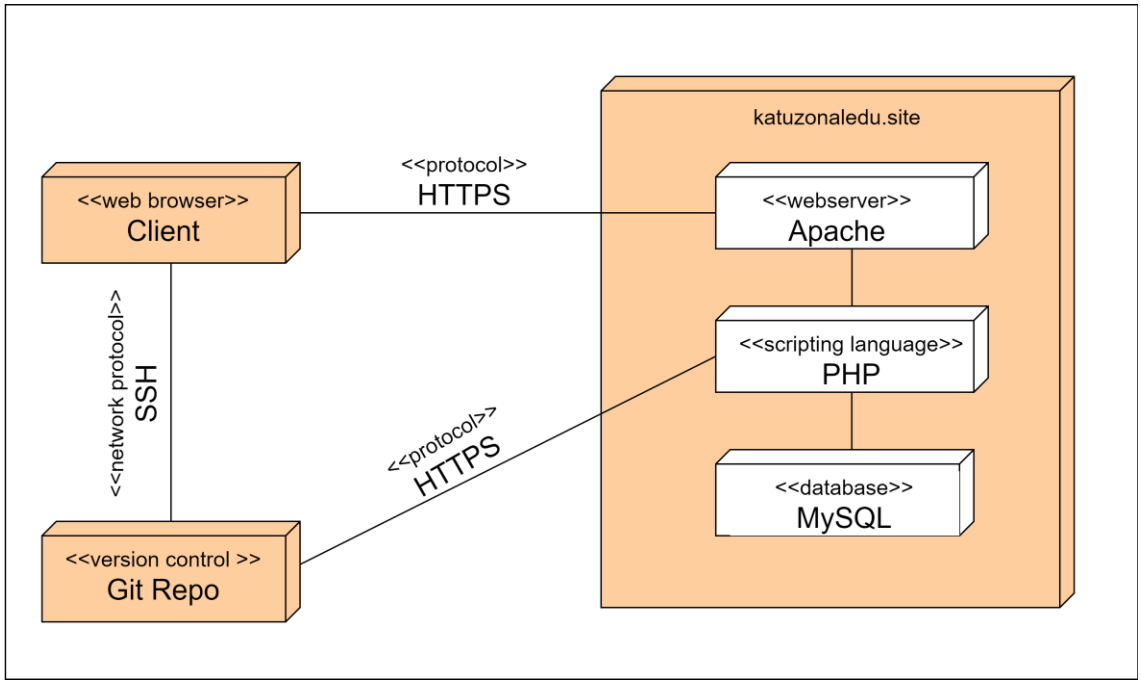

Fig. 3 UML deployment diagram

Training session and documentation is helpful in the adoption of the new system. Seven employees at the Zonal Education Office, Katugastota participated in the training session. This training session was successful and all the employees were trained well. The tasks in the web application were practised by using dummy data in the training session. Finally, the user manual documentation was created and it was distributed among the employees.

V. Future Works

Following future improvements were considered,

- Currently, the web application is deployed under the domain name https://katuzonaledu.site, Therefore, it will be changed to country code top-level domain (ccTLD).
- Currently, the web-based system is not collaborating with the mobile application. Therefore, the mobile application will be developed by adding specific features. The proposed features for the mobile application are instant announcement receiving, an organizational phone book and organizational event reminder and a VR (Virtual Reality) feature to explore the places of the *Zonal Education Office, Katugastota*.
- The web application is using FAQ section to respond to frequently asked questions (FAQs). Therefore, AI (Artificial Intelligent) chatbots will be implemented in the near future to respond to the questions that the users ask the chatbot.
- This web application is currently supporting only the 'Light mode'. Therefore, 'Dark mode' also will be implemented in the near future to change the mode of the web application based on the user preference.

VI. Conclusion

The role of this interactive web application was to provide a lightweight, smooth, fluid UI (User Interface) web experience for the organization by ensuring a customizable experience, reducing maintenance costs by building a dynamic web experience, reducing complexity and providing identified requirements and improving usability by ensuring overall security.

The average success rate of selected test cases used during unit testing, integration testing, and system testing are shown in *Fig. 4*. The results demonstrate the effectiveness and accuracy of this web application. All these test cases relate to testing each selected feature and function independently, as well as testing each test case in accordance with the testers' personal preferences.

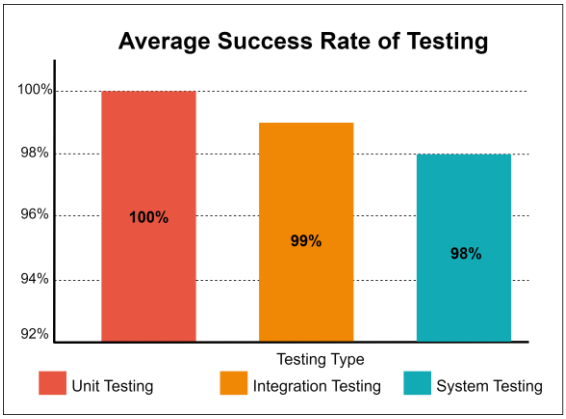

Fig. 4 Average success rate of test cases

Furthermore, the evaluation of the system was done by engaging the organizational approval and reviewing committee. Therefore, three methods were used to evaluate the web application [26]. They were questionnaires, design reviews and comparing the main functionalities with the identified similar 5 systems *(Table VI)*.

Moreover, other organizations mentioned in Table VI used several content management systems (CMS) to build their web solutions but a custom dynamic web application was developed in this project based on unique organizational operations. Therefore, it reduces the complexity and the maintenance cost of the web application for this organization.

According to the methods of evaluation, the responses were positive. Therefore, the client achieved their organizational needs via this web application. Furthermore, this web application development project fulfilled the requirements and aims and objectives of the proposed system.

TABLE VI
COMPARISON OF FEATURES IN THE SELECTED ORGANIZATIONAL WEB SOLUTIONS IN SRI LANKA WITH THIS WEB APPLICATION

	Ministry of Education, Sri Lanka	**Department of Irrigation, Sri Lanka**	**Ministry of Higher Education, Sri Lanka**	**Information and Communication Technology Agency (ICTA) of Sri Lanka**	**Zonal Education office, Hingurakgoda, Sri Lanka**	**Zonal Education Office, Katugastota.**
Responsive Web Design (RWD)	Yes	No	Yes	Yes	Yes	Yes
Search Engine Optimization (SEO)	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Security Enhancements	HTTPS used	HTTPS used	HTTPS used	HTTPS and Google reCAPTCHA used	HTTPS used	HTTPS and reCAPTCHA were used.
Colour Scheme	Monochromatic colour scheme	Not used	Logo-based colour scheme	Logo-based colour scheme	Monochromatic colour scheme	Logo-based colour scheme
Web design Patterns and theories.	Z-pattern layout, F-pattern layout, grid structure	F- pattern layout	Z-pattern layout, F-pattern	Grid Structure	Grid Structure	F-pattern layout, Z-pattern Layout, minimalist web design and gestalt principles

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