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Web system for vehicle management in a University Center

Sistema web para la gestión vehícular en un Centro Universitario

ZAMORA-RAMOS, Víctor Manuel[1]†*, JIMÉNEZ-RODRÍGUEZ, Mario[1], PULIDO-GONZÁLEZ, Hector[1] and MACÍAS-BRAMBILA, Hassem Rubén[2]

[1]*Universidad de Guadalajara – Centro Universitario de Ciencias Exactas e Ingenierías, Blvd. Marcelino García Barragán No. 1421, Col. Olímpica, CP 44430*
[2]*Universidad Tecnológica de Jalisco – Av. Luis J. Jiménez No. 577, Col. Primero de Mayo, CP. 44970, Guadalajara, Jalisco. México*

ID 1st Author: *Victor Manuel, Zamora-Ramos* / **ORC ID**: 0000-0001-9537-6630, **CVU CONAHCYT ID**: 903643

ID 1st Co-author: *Mario, Jiménez-Rodríguez* / **ORC ID**: 0000-0001-5073-473X, **CVU CONAHCYT ID**: 1044155

ID 2nd Co-author: *Héctor, Pulido-González* / **ORC ID**: 0000-0002-8619-3012, **CVU CONAHCYT ID**: 313575

ID 3rd Co-author: *Hassem Rubén, Macías-Brambila* / **ORC ID**: 0000-0002-6540-7464, **CVU CONAHCYT ID**: 902812

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Abstract

This article presents the development process of a web application designed to manage the entrances and exits of institutional vehicles at the University Center for Exact Sciences and Engineering of the University of Guadalajara, under the supervision of the Coordination of General Services. A detailed description of the analysis, design and development of the project is provided. The web application was developed in the Mobile Programming and Innovation Laboratory, with the purpose of digitizing and automating the vehicle registration and control process, replacing the manual filling of sheets or folios with an efficient web system. The main objective of the project was to improve the efficiency and precision in the registration of departures and returns of vehicles, through the capture, storage and consultation of various data related to drivers, vehicles, itineraries, fuel, tools and equipment, mileage, among others. Relevant aspects for vehicle control. The development of the project was carried out applying the agile SCRUM methodology, which is characterized by its focus on adaptability, iterative delivery, effective collaboration, value generation and efficient risk management. SCRUM allowed greater flexibility in development, ensuring customer satisfaction and alignment with their needs and expectations.

Scrum, Software, Web System

Resumen

El presente artículo presenta el proceso de desarrollo de una aplicación web diseñada para gestionar las entradas y salidas de vehículos institucionales en el Centro Universitario de Ciencias Exactas e Ingenierías de la Universidad de Guadalajara, bajo la supervisión de la Coordinación de Servicios Generales. Se brinda una descripción detallada del análisis, diseño y desarrollo del proyecto. La aplicación web se desarrolló en el Laboratorio de Programación e Innovación Móvil, con el propósito de digitalizar y automatizar el proceso de registro y control vehicular, sustituyendo el llenado manual de hojas o folios por un sistema web eficiente. El objetivo principal del proyecto consistió en mejorar la eficiencia y precisión en el registro de salidas y retornos de vehículos, mediante la captura, almacenamiento y consulta de diversos datos relacionados con conductores, vehículos, itinerarios, combustible, herramientas y equipo, kilometraje, entre otros aspectos relevantes para el control vehicular. El desarrollo del proyecto se llevó a cabo aplicando la metodología ágil SCRUM, que se caracteriza por su enfoque en la adaptabilidad, entrega iterativa, colaboración efectiva, generación de valor y gestión eficiente del riesgo. SCRUM permitió una mayor flexibilidad en el desarrollo, asegurando la satisfacción del cliente y la alineación con sus necesidades y expectativas.

Scrum, Software, Sistema Web

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*Correspondence to Author (e-mail: victor.zamora@academicos.udg.mx)
† Researcher contributing as first author.

Introduction

The efficient management of general services plays a fundamental role in the optimal functioning of any educational institution or academic center. In this sense, the Centro Universitario de Ciencias Exactas e Ingenierías (CUCEI) has faced challenges in the Coordination of General Services (CSG), specifically in the control and registration of entry and exit of official vehicles. Currently, a paper-based registration system is used, in which drivers must manually complete information on related administrative tasks, such as the acquisition of supplies or the distribution of personnel. However, this approach presents several limitations and challenges that affect the efficiency and accuracy of vehicle control management. Some of the problems identified include:

– Inefficient operations: The manual process of filling out the log sheets takes considerable time, which negatively affects the efficiency of vehicle control management. The personnel in charge must spend a significant amount of time manually capturing data, which slows down operations and limits responsiveness.

– Risk of transcription errors: When completing log sheets manually, there is an increased risk of transcription errors. These errors can affect the accuracy and reliability of the recorded data, which could have adverse consequences on decision making and planning of vehicle services.

– Difficulty in accessing and consulting information: With the paper-based system, accessing and consulting the necessary information becomes a tedious process and limited in terms of availability. Authorized personnel must search and review the physical sheets, which hinders agile decision making and efficient planning of vehicle services.

Faced with this problem, the CSG has sought a solution through collaboration with the Mobile Programming and Innovation Laboratory (CuceiMobile), which is part of the CUCEI and aims to develop software solutions on various platforms for the benefit of the university community.

Methodology

The development of the project took place in 2021 and the SCRUM methodology was adopted. This methodology, defined by Schwaber and Sutherland (2020) as a "framework within which people can address complex and adaptive problems while delivering products productively and creatively," is characterized by its adaptability, focus on iterative delivery, effective collaboration and communication, generation of business value, and efficient risk management. These attributes resulted in successful project execution, enabling greater efficiency, accuracy and customer satisfaction. The roles played in the project were as follows:

– Scrum Master: This figure assumes responsibility for ensuring the correct implementation of the Scrum process and removing obstacles that may arise during development. In the case of this project, the role of Scrum Master was played by the Director of CUCEI Mobile.

– Product Owner: The Product Owner represents the interests of the customer and is responsible for defining and prioritizing product requirements. In the context of the project, the CSG assumed the role of Product Owner, ensuring the objectives and needs of the institution.

– Development Team: This team, composed of 3 members, was responsible for carrying out the tasks necessary to deliver the product increments. Their work involved the implementation of the proposed software solutions, as well as the resolution of technical challenges and the optimization of the final result.

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The combination of these roles, properly coordinated and closely collaborating, allowed the smooth progress of the project, the adaptation to changes and the achievement of the established objectives. The application of the SCRUM methodology in the development of the vehicle control management project at CUCEI has proven to be an effective approach to achieve a successful and satisfactory execution of the project.

Analysis

The first component developed was the Product Backlog, which integrates the information provided by the client and relevant to the project. In this phase, the functions to be implemented, the specific requirements to be met and their priority are described. Requirements determination, as defined by Sommerville (2016), is the process of discovering, analyzing, documenting and verifying the services, constraints and system needs to be met by a software product. This process is fundamental in software development, as it lays the foundation for system design, implementation and testing.

It is essential to understand and clearly define the system requirements to ensure that the software meets customer expectations and needs for requirements gathering, we used interviews with drivers, the vehicle fleet manager, and the general services coordinator were used to gather requirements. In addition, a documentary analysis of the printed forms used for vehicle registration and the electronic documents generated was carried out.

Once the interviews and the printed and electronic formats were obtained, the findings were classified and categorized, which resulted in the integration of the Software Requirements Specification (ERS) document using the IEEE Std 830-1998 template of the Institute of Electrical and Electronics Engineers (IEEE, 1998). This document specifies the different types of users, their characteristics, the scope of the system and both functional and non-functional requirements. Tables 1 and 2 show an extract of specific requirements.

Number	R.F.1
Name	Create user
Type	[X] Requisite [X] Restriction
Source	Interview 13/01/20 Record 10
Priority	[X] High [ ] Medium [ ] Low

Table 1 Functional Requirement 1

Number	R.F.2
Name	Register Output
Type	[X] Requisite [ ] Restriction
Source	Interview 13/01/20 Record 14
Priority	High Medium Low [X] [ ] [ ]

Table 2 Functional Requirement 2

Subsequently, the Sprint Backlog was defined, which is a document containing the list of tasks to be performed assigned to the team members in charge of developing them. The completion times for each task were specified and a Gantt chart was created for better organization. Within the Scrum methodology, a Sprint is a period of time, usually short, in which the development team works on a set of activities related to the system being designed. The duration of Sprints can be four weeks or even shorter, depending on the complexity of the project. Sprints determine the deliverables and allow module testing to be carried out.

In each Sprint, a Sprint Planning meeting is held, in which the team and the Product Owner participate to define the objectives, select the user stories and backlog items to be included in the Sprint. Team members met daily in the Daily Scrum (daily meeting) to share progress, plan tasks for the next meeting and discuss any impediments that have arisen in the execution of the plan. These meetings should last no longer than 15 minutes. For work management, the Kanban methodology, defined by Taiichi (1988), was used, which helps the development teams to visualize, limit and optimize work by creating notes with the tasks on a board composed of sections such as "to do", "in progress", "tested" and "finished".

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Design

In this phase of the project, the architectural design of the application is carried out, focusing both on its general structure and on the organization of the data in the Database.. The process begins with the development of a block diagram that provides an overview of the modules or fragments of functionality and/or models of the application. This diagram is useful for determining the data flow, process inputs and outputs. Figure 1 shows the blocks of the developed system.

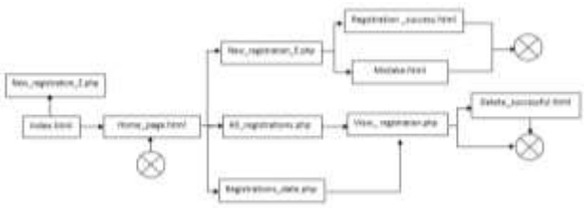

Figure 1 Block Diagram

Subsequently, a class diagram is elaborated to provide a more specific level of detail. According to Rumbaugh *et al*. (2007), this diagram is composed of the classes that make up the system, including their attributes, methods and relevant relationships. This approach allows the precise identification of the classes necessary for the system to function, as well as the auxiliary fragments that may be required.

The architectural design focuses on establishing a solid and coherent structure for the application, defining the interactions between the different components and ensuring that data is stored and accessed efficiently in the database. This design provides a clear view of the organization and functionality of the system as a whole. To provide greater detail, Class-Responsibility-Collaboration Cards (CRC) were used. These cards are used to describe the nature of each class and the relationships to be maintained in the system. Table 3 corresponds to the CRC card of the user class.

Clase:	Usuario
Responsabilidad	**Colaboración**
-Registrar Vehículo	-Vehículos
-Registrar Salida	-Mantenimientos
-Registrar Entrada	-Movimiento
-Registrar Falla	

Table 3 User Class CRC Card

For the modeling of the scenarios in which users interact with the system, a use case diagram was used. This type of diagram allows to graphically visualize the interactions between the actors and the system, which provides a clear view of the responsibilities of each user. The use case diagram models the behavior that the system will have, see Figure 2.

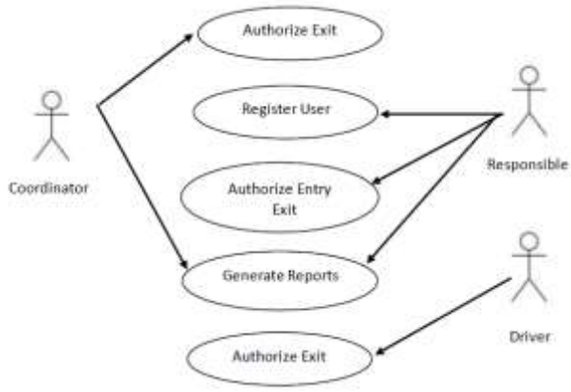

Figure 2 Use Case Diagram

As a complement to the use case diagrams, a detailed definition of each one of them was made. In this documentation, the activities of the actor and the activities of the system, as well as the alternative

The actor's activities and the system's activities were specified, as well as the alternative conditions that may arise. The project documentation was elaborated based on the diagrams that integrate the Unified Modeling Language (UML).

In addition, several activities were carried out in this design to ensure its correct implementation. These activities included the identification of actors, entities and object communication, as well as the use of the UML development standard to represent the use cases. In the area of semantic data design, an entity-relationship diagram was developed to define the logical structure of the data, as well as a relational model and the definition of the data for the database. data for the database.

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Development

The application development phase was carried out in collaboration with students participating in the social service at CuceiMobile. During this stage, the Visual C++ programming language was used for the coding of the site, while the database manager used was MariaDB.

In order to achieve an efficient user interface design, we implemented the pattern Model-View-Controller (MVC) pattern was implemented. This design This design pattern is widely recognized in software engineering and is used to manage user interactions, present data in an appropriate manner and ensure proper communication with the domain layer. The MVC pattern divides the application into three main components: the model, which represents the data and business logic; the view, responsible for presenting information to the user; and the controller, which acts as an intermediary between the model and the view, managing interactions and updates.

The choice of Visual C++ as the programming language and MariaDB as the database manager was based on its wide adoption in the field of application development environment and its ability to provide a robust and efficient environment. In addition, the implementation of the MVC pattern in the user interface design ensured an organized and modular structure, facilitating the maintenance and scalability of the system.

The collaboration with the student social service providers in CuceiMobile not only provided a learning opportunity and hands-on experience for the participants, but also allowed the development of the application in a collaborative manner, fostering the exchange of knowledge and skills. This collaboration reflects the importance of the active participation of the academic community in software development projects, promoting the integral formation of students and strengthening the ties between academia and industry.

Access to the web portal is with the link: http://148.202.152.33/ControlVehicular/Index.html, the user to enter must log in, as shown in Figure 3.

Figure 3 Portal access view

The application interface plays a key role in the registration and tracking of vehicles, providing various functionalities to optimize the management of vehicle services at CUCEI. Among the main features are:

- Creation of vehicle output records: The person responsible for the general services area has the ability to generate output records for official vehicles. These records contain relevant information, such as the reason for the departure, the destination and the estimated duration of the trip. This data is essential to keep accurate control of vehicle travel and effectively plan resources.

- Authorization of records: Departure logs generated by the area manager must be authorized by the CSG holder before vehicles can depart. The purpose of this authorization is to ensure that departures are carried out in accordance with established policies and regulations, thus guaranteeing the proper use of vehicles and the optimization of institutional resources.

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– Consultation of generated records: The main interface allows access to all vehicle departure records in the system. This function facilitates the review and tracking of the departures made, providing an overview of vehicle movements in the school. In addition, additional details can be obtained for each record, such as the assigned driver, mileage and associated comments.

– Date-specific search: To speed up information retrieval, the main interface also offers the possibility to perform date-specific searches. This functionality allows filtering of vehicle output records according to a specific date range, which is useful for analyzing travel history over a given period or for specific reporting.

The implementation of these functionalities in the main interface, as shown in Figure 4 of the application, contributes significantly to improve the efficiency and accuracy in the management of vehicle services. and accuracy in the management of CUCEI's vehicular services. In addition, the use of a digital system for vehicle registration and tracking offers obvious advantages compared to traditional paper-based methods, such as reduced transcription errors and increased availability and accessibility of recorded information. This aligns with current developments in the field of general service management and the adoption of technological solutions that improve operational efficiency and promote data-driven decision making.

Figure 4 Main interface

The creation of records in the application is carried out using the following excerpt from the user interface shown in Figure 5.

Figure 5 Record Creation

The creation of logs is a fundamental step in the process of managing vehicle services, as it allows for the accurate documentation and recording of information related to vehicle departures. This information is not only necessary to keep proper control of trips, but also provides valuable data for analysis and decision making in fleet management.

The user interface designed for log creation has an intuitive the user interface designed for the creation of records presents an intuitive and user-friendly structure, facilitating the capture of relevant data. Specific fields and options have been implemented to allow the necessary information to be entered efficiently. In addition, usability and user-centered design principles have been applied to ensure a smooth and satisfactory experience during the registration process.

The design of effective and efficient user interfaces is a widely studied topic in the field of Human-Computer Interaction (HCI). Various theories and methodologies supported by scientific research, including Norman (2013), Shneiderman and Plaisant (2009) have demonstrated the importance of a user-centered design that is tailored to the needs, abilities and expectations of users. The use of intuitive and well-designed interfaces not only improves efficiency and accuracy in data capture, but also contributes to user satisfaction and error reduction.

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In short, the creation of records in the application is done through a carefully designed and user-friendly user interface user interface. The record view provides a detailed and visual description of this interface, giving users a practical guide to use it correctly and effectively. The focus on user-centered design and the application of usability and intuitive design principles ensure an optimal experience during the registration process, thus improving the quality of the data collected and facilitating the management of vehicle services.

The web application allows users to access the registration information generated through data query. The ability to query the records generated in the web system is of vital importance for the management and monitoring of the activities related to vehicle services. Through this functionality, users can quickly access the necessary information and perform data-driven analysis for informed decision making. This interface features graphical elements and filtering options that facilitate efficient search and retrieval of information. Intuitive and user-friendly controls, such as search fields, filters by relevant criteria and sorting options, have been implemented to allow smooth navigation and exploration of records.

In addition to general record queries, the system also offers the ability to perform date-specific queries. The ability to query by date is very useful in the management of in the management of vehicle services, as it allows users to obtain specific records within a given time range. This facilitates the identification of patterns, the generation of reports and the evaluation of performance over specific periods.

Testing

For Pressman (2014) software testing is a systematic evaluation process to determine the quality of a software system or component. This process involves the execution of a program or system with the intention of discovering errors, evaluating its behavior against established requirements, and ensuring that it meets its intended objectives. Thus, the web system was subjected to rigorous testing at various stages of the development process, from requirements verification to final acceptance testing. These tests played a key role in identifying and correcting errors and problems before the final implementation of the system.

In the initial stage, verification testing was performed to ensure that the system met the requirements set forth in the Software Requirements Specification (SRS) document. These tests focused on validating the main functions, such as user creation and vehicle registration, verifying that they were carried out accurately and without errors. Non-functional requirements, such as security and usability, were also evaluated to ensure compliance and adequate performance. Subsequently, integration tests were carried out in order to evaluate the interaction between the different components of the system. During this phase, it was verified that the communication between the modules and the database worked correctly, ensuring that the data were stored and retrieved properly. In addition, tests were performed to detect any conflicts or incompatibilities between the system elements, in order to ensure that they were properly integrated and worked together.

Once the integration tests were completed, we proceeded to perform system tests, the objective of which was to evaluate the overall functioning of the system.

The objective of these tests was to evaluate the overall performance of the system. During this phase, real use situations were simulated to evaluate the performance, scalability and stability of the system. The system was tested to ensure that it could efficiently handle a high volume of vehicle check-ins and check-outs, and that it responded quickly and appropriately to user requests.

Finally, acceptance tests were carried out, in which the CSG actively participated. These tests were conducted to ensure that the system met the organization's specific expectations and needs. The presence and functionality of all required features was verified, as well as the ease of use and intuitiveness of the system for end users. CSG's comments and suggestions were considered and the necessary corrections were made before the final implementation of the system.

In summary, software testing played a critical role in the process of developing the web system for the CSG. These tests ensured the quality and efficiency of the system by identifying and correcting errors at different stages of development.

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They also ensured compliance with the established requirements and usability of the system for CSG users. Through the application of exhaustive tests, a reliable and functional system that meets the organization's needs was obtained.

Results

The use of the Scrum methodology in the development of the vehicle control application provided positive results in terms of adaptability, iterative value delivery, effective collaboration, value generation and efficient risk management. These results contributed to the success of the project by ensuring customer satisfaction, early delivery of valuable functionality, and adaptation to the changing needs of vehicular control.

The use of the IEEE Std 830-1998 template in the development allowed for complete and accurate documentation of the system requirements. As well as the interviews allowed for effective communication between the development team and the between the development team and the customer to understand the needs and expectations of the end users.

For the selection of the development environment used for the construction of the web system, as well as the database the selection of the development environment used for the construction of the web system, as well as the database manager had no restrictions, however, we opted for the use of free access technologies, since it facilitates the adaptation as it does not represent costs for the acquisition of licenses.

The use of the controller view model allowed the delimitation of responsibilities, code reuse, ease of testing, flexibility, scalability, and collaboration among project members. All this contributed to make the development more structured, modular, maintainable; which facilitated the delivery of a higher quality software product, facilitating future modifications and improvements in the system.

To ensure access, efficient management, consistency, quality, integration, security, and data access control, it was determined that data storage would be centralized, providing a solid basis for analysis and informed decision making.

By having all data in one place, it is easier to perform queries, generate reports and obtain a holistic view of the information, which can help in identifying patterns, trends and opportunities for improvement.

The designed interfaces offer efficient search and retrieval functionalities, allowing users to access and analyze the information in the records in an intuitive way. The inclusion of visual annexes in the article supports readers' understanding and strengthens the validity of the research presented.

The use of exhasaustive software testing in the development of the web system enabled early detection of bugs, improved software quality, reduced risks, saved time and costs, increased client confidence, and facilitated system maintainability. This contributed to more efficient, reliable and successful software development.

Conclusions

The implementation of the web system for the General Services Coordination at the University Center of Exact Sciences and Engineering has proven to be a highly effective and successful solution to optimize the management of official vehicle departures.

In terms of the results obtained, there has been a clear improvement in the efficiency of operations related to vehicle control. The automation of the vehicle check-in and check-out process has significantly reduced the time required to carry out these activities. This has allowed a more agile management of resources and a faster response to the demands of the educational center.

In addition, a considerable increase in data accuracy has been observed. The elimination of the manual process of recording on paper sheets has reduced the likelihood of transcription errors. As a result, the information recorded in the system is more reliable and accurate, which has improved decision making based on up-to-date and accurate data. Another important benefit of the system is the ease of access and consultation of the information. Thanks to the web-based system, authorized users can access vehicle records quickly and easily, eliminating the need to search and review physical sheets.

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This has saved time and improved the ability to search and retrieve relevant information, which is essential for efficient and effective management.

In conclusion, the implementation of the web-based system at CSG has proven to be a highly beneficial solution to optimize the management of official vehicle departures. The agile methodology used, the results obtained in terms of efficiency and data accuracy, as well as the ease of access and consultation of the information, support the effectiveness and positive impact of this system at the University Center for Exact Sciences and Engineering.

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