Black Box Testing in Community Service Systems Using Boundary Value Analysis and Cause Effect Graph Methods (Case Study of Jombang District Community and Village Empowerment Service)

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A R T I C L E I N F O

A B S T R A C T

The community service information system at the Jombang Regency Community and Village Empowerment Service is an accurate and interactive information medium for the community and has been integrated with the village fund management system. So it is necessary to maintain the quality of the system so that it runs according to the expected functionality and runs optimally. Testing focuses on system functionality and performance using Black Box Testing with Bodary Value Analysis and Cause Effect Graph methods. Based on the test results, the use of Cause and Effect Graphs in public service information systems is more dominant for testing data entry features, and features in the form of buttons. Meanwhile, Boundary Value Analysis is more dominant in testing features that have a range such as name or title input, caption input, and complaint message input and obtained an effectiveness value of 77.86%, which is in the quite effective category and still needs to be done. improved and developed so that the system can be successful. achieve maximum effectiveness values so that functionality runs more optimally.

INTRODUCTION

Along with the development of technology and information sources, internet media is now very popular with the public and business people. One of the internet media that is fast in disseminating information is an information system. Information systems can be used at various levels and functional areas in an organization, such as management information systems, marketing information systems, financial information systems, production information systems, and so on. The main goal of an information system is to provide relevant, accurate, timely and useful information to users to support decision-making, control and organizational operations.

Information systems can not only be used by large companies and institutions, but now regional organizations also have information systems as a medium for information and services to the community. One of the regional organizations that has a service information system is the DPMD (Community and Village Empowerment Service) of Jombang Regency. The community service information system at the Jombang Regency Community and Village Empowerment Service is an information system where this service system is used as an accurate and interactive information medium with the community and has been integrated with the village fund management system. The benefits of this public service system are that it can facilitate access to public information, increase the efficiency of public services, and increase community participation in village government. This DPMD community service information system functions in comparing and introducing more information to the community regarding the Jombang Regency Community and Village Empowerment Service, providing updated and accurate information as well as presenting documents needed by the community, such as documents on procedures for applying for village funds.

These documents can be accessed by the community easily through this system. Apart from that, the DPMD community service information system is equipped with a message box feature where with the message box feature, the community can provide suggestions, complaints or complaints regarding village problems such as damage to several village facilities and infrastructure. Before the existence of this community service system, there was limited interaction between agencies and the community. Previously, the Jombang Regency Community and Village Empowerment Service was unable to inform the community regarding regulations and updated information regarding villages and the community was unable to provide any complaints and complaints that were needed for the development and development of village facilities and infrastructure. After the existence of this community service information system, the Jombang Regency Community and Village Empowerment Service can provide all the latest information and regulations relating to villages and the community can provide suggestions, complaints and complaints to the Jombang Regency Community and Village Empowerment Service regarding village needs and requirements.

Due to the importance of the DPMD community service information system in the field of village empowerment and the development of village

facilities and infrastructure, it is necessary to maintain the quality of the system by testing the system to ensure whether the system is running according to the functionality expected by the agency and to find deficiencies in the system. so that it can be improved so that system functionality runs more optimally.

According to (Bekiroglu, 2017) software testing is a series of planned processes and the aim of this process is to find bugs in a system. Testing is divided into 3 types, namely Black Box, White Box and Gray Box testing. White Box testing is a test that shows how the product works in detail according to its specifications. Meanwhile, Gray Box testing is a combination methodology of Black Box and White Box Testing, testing software based on specifications but using internal working methods (Dhaifullah et al., 2022). Testing using the Black Box Testing method is suitable for use in public service information systems at the Jombang Regency Community and Village Empowerment Service because Black Box Testing is a method that focuses on testing functionality without looking at the code structure in detail. The Black Box software testing method is based on software specifications (Bekiroglu, 2017). The Black Box Testing method itself has several techniques, including Equivalence Partitioning, Boundary Value Analysis / Limit Testing, Comparison Testing, Sample Testing, Robustness Testing, Behavior Testing, Requirement Testing, Performance Testing, Endurance Testing, Cause Effect Relationship Testing / Cause Effect Graph Testing (Safitri & Pramudita, 2018). However, examiners will focus on Boundary Value Analysis and Cause Effect Graph techniques also known as Cause Effect Relationship. Testing was carried out by combining the two methods because both methods are relatively easy methods as a starting point for testing and no one has conducted research using a combination of the two methods.

Research related to the Cause Effect Graph was carried out by (Bekiroglu, 2017) who discussed software testing tools using the Cause Effect Graph method. Explained the analysis of the Cause Effect Graph method along with examples of its implementation. The Cause Effect Graph testing tool is a software testing tool that uses the Cause Effect Graph software testing method. The Cause Effect Graph software testing tool provides a systematic way to combine input conditions. The combination of different input conditions can reveal new bugs that may not be discovered with other methods of generating software test cases. With automated software testing tools, software testing can be carried out more systematically and correctly. Although many processes can be automated with software testing tools, Cause Effect Graph software testing tools still require many manual processes such as determining input conditions and developing logical circuits which also require analysis of constraints on input conditions.

Research related to Boundary Value Analysis was carried out by (Jimi Asmara, 2019) which discussed application testing at the Lampung State Polytechnic Digital Office using Boundary Value Analysis. This testing includes design, specifications, and coding. This research aims to test digital office software at the Lampung State Polytechnic. The testing process is carried out to determine the level of errors that occur in the software. This test uses Black Box

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Testing Boundary Value Analysis. Boundary Value Analysis is a type of test case that determines the normal value, minimum value and maximum value of the data to be tested. The application can handle data, both normal data and abnormal data with a success percentage of 91.67%.

This research is different from previous research, namely, the research was carried out by combining the Boundary Value Analysis technique and the Cause Effect Graph technique with an application to different objects, namely the information system of the Community and Village Empowerment Service of Jombang Regency, the use of the Cause Effect Graph technique is used when there are many variations. test the application and is equipped with Boundary Value Analysis as a determinant of the upper and lower input limits. It is hoped that in this test several errors will be found which can later be corrected and optimize the functionality of the community service information system of the Jombang Regency Community and Village Empowerment Service.

THEORETICAL REVIEW
Information Systems

An information system is a series of formal procedures that involve collecting data, then processing it into information, and then distributing it to users. An information system is a system that collects, processes, controls and processes data from various operational activities, both those that occur within the organization and outside the organization. The output produced from this information system is in the form of reports required by management. (Priharta, et al., 2021).

Information is data that is processed in such a way that it becomes a form that is more useful and meaningful for the recipient, and can help the recipient in their daily lives. (Simamarta, 2020). Information has meaningful value when it can be used to make good decisions. For example, such as student grades, lecture schedule announcements, salary calculations based on working hours, information that carrot juice drinks are rich in vitamin A, and so on. (Dedy Rahman Prehanto, S.Kom., 2020).

According to (Tata Sutabri, 2016), information is considered quality if it meets the following requirements:

a. *Accurate*

Information is considered quality if it is free from errors, is not biased or misleading, and has clarity in reflecting the meaning of the information. This is due to the possibility of interference in the journey of information from the source to the recipient, which can cause damage to the information obtained.

b. *On Time*

The information received must not be late, if it is late, the value of the information is not there. Information is one of the considerations in decision-making. If information is received late, this can hinder the decision-making process and have serious impacts on the organization.

c. *Relevant*

The relevance of information varies from one individual to another, as well as from one division to another, so information must be

conveyed to the appropriate recipient. For example, information about machine breakdowns will be more relevant to engineering staff in a company than to administrative staff.

Information systems consist of five components, namely hardware, software, data, procedures and people (Rahmawati & Bachtiar, 2018).

 a. Hardware (hardware), includes various physical equipment such as computers and printers.

 b. Software (software), in the form of certain commands intended to instruct components to carry out their tasks.

 c. Data is the most basic or raw component of information that will be processed further so that it can be meaningful and produce information.

 d. Procedures are rules used to connect various kinds of commands and data to determine the design and use of information systems.

 Humans are implementers, namely those involved in information system activities such as operators, leaders, and so on.

Black Box Testing Method

Black Box Testing is software testing that focuses on the specifications of the functions in the software being developed. Black Box tends to be able to find several things such as incorrect or missing functionality, data structure errors, database access errors, interface design errors, and performance errors. Black Box testing focuses on system function. (Ikhlaashi & Putro, 2019).

Figure 1 below illustrates the black-box testing process, which is a software testing method that focuses on the specifications of the functions in the software being developed. Black-box testing places more emphasis on system functions. This method is used to determine whether the software is functioning properly. Black box testing is a method of designing test data that is based on software specifications. Test data is executed on the software and then the output from the software is checked whether it is as expected.
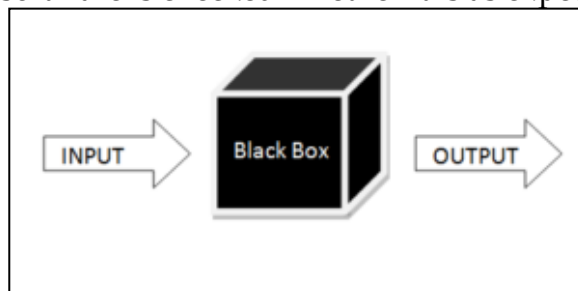

Figure 1. Black-Box Testing Flow
(Source : https://raharja.ac.id)

The Black Box Testing method consists of 10 types of testing techniques, including:

a. *Equivalence Partitioning.* This technique works by dividing input data from several software into several data partitions

b. *Boundary Value Analysis / Limit Testing.* This technique focuses on finding errors from outside or inside the software. The Boundary Value Analysis technique is a complement to Equivalence Partitioning.

c. *Comparison Testing.* Comparison Testing is a technique that tests each version with the same data to ensure that all versions produce the same output.

d. *Sample Testing.* Sample Testing is a technique that involves several selected values from an equivalent class.

e. *Robustness Testing.* Robustness Testing is a technique that aims to prove that there are no errors if the input is invalid. The input data is selected outside the defined specifications.

f. *Behavior Testing.* Behavior Testing is a technique that must be carried out several times because the test results cannot be evaluated if you only test it once, for example when testing a stack data structure.

g. *testing Requirements.* Requirement Testing is a technique used to specify requirements and designs associated with software.

h. *Performance Testing* is a technique for evaluating a program's ability to operate correctly in terms of reference requirements, for example, data flow, memory usage size, and execution speed.

i. *Endurance Testing.* Endurance Testing is a technique that involves repeating test cases a certain number of times.

j. *Cause Effect Graph Testing.* Cause Effect Graph Testing is a technique for dividing requirements specifications into parts that have the possibility of working. (Hanifah et al., 2016)

Cause Effect Graph

Cause Effect Graph is a testing technique by conducting trials based on logical conditions and related actions (Safitri & Pramudita, 2018). The Cause Effect Graph method helps in planning efficient and comprehensive testing by paying attention to the interactions between parameters that influence each other in the system. By using this technique, testing can be carried out with a smaller number of test cases but still includes relevant and significant test combinations.

This method is especially useful in testing complex software, where many variables and combinations may influence system behavior. By using a Cause Effect Graph, testing can be carried out more focused and efficiently, thereby helping to identify defects or problems in the software more effectively. The stages in the Cause-Effect Graph include:

a) Identify input conditions (cause) and output conditions (effect).

b) Describe the relationship between cause and effect using a cause and effect graph.

c) The cause and effect graph is converted into a decision table.

d) The rules in the decision table are converted into test cases (Munandar et al., 2022)

METHODOLOGY

The stages carried out start from literature study, analyzing system requirements, identifying the functionality to be tested, determining test

conditions, creating test cases, carrying out Black Box testing with Boundary Value Analysis and Cause Effect Graph, and getting test results in the form of effectiveness values, recommendations for improvements, as well as designing improvements and then making a final report. The following is a picture of the research flow display which can be seen in Graph 1 below:
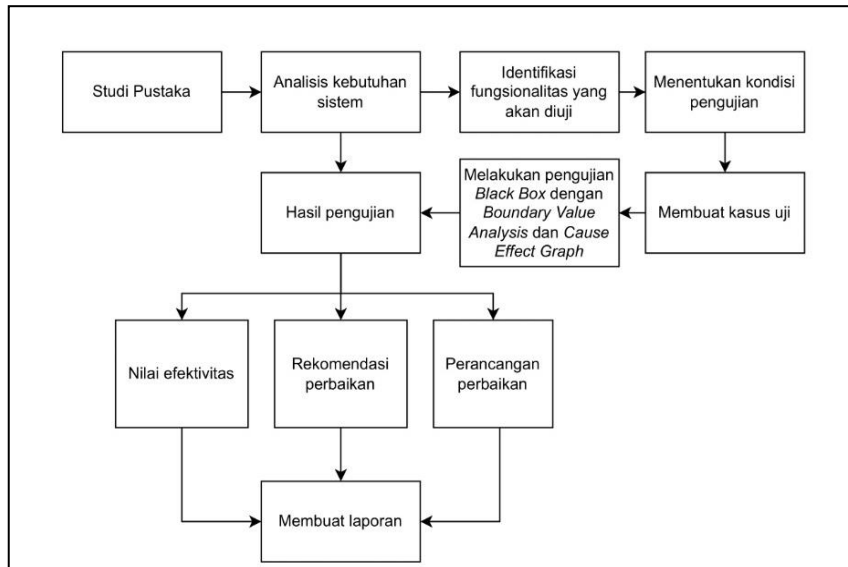
Graph 1. Research Flow

RESULTS AND DISCUSSION
Improvement Recommendations

The following is a list of system weaknesses found by examiners in the community service information system of the Community and Village Empowerment Service of Jombang Regency accompanied by recommendations for improvement.

Table 1. System Weaknesses and Recommendations for Improvement

No	System Weaknesses	Improvement Recommendations
1.	On the login page, you can still save data with the username and password using all capital letters and a combination of upper and lower case letters	Added case sensitivity to the login form to maintain program security
2.	On article pages accessed by the public, article updates do not display the latest articles	Make sure that articles can be updated regularly in the article updates section
3.	On articles, photos, videos, and document pages that are accessed by the public, when you search with an incorrect value you can still display the entire search	Fixed the search function so that when searching with an incorrect value no data is found
4.	On the page managing headers, articles, photos, videos, documents, and fields accessed by the admin, performing a search with an incorrect value can still display the entire search	Fixed the search function so that when searching with an incorrect value no data is found
5.	On the photo, document, field management page, which is accessed by	Fixed the date section so that it is updated according to the upload date of

	the admin, the date cannot be updated and everything has changed	photos, documents and fields
6.	All input photos in the system can still be filled in in jpeg input format and do not comply with the specified test condition limits	Provide information if it can only accept files and photos with a certain format and size, but it is better to make it able to upload in many formats
7.	On the header page accessed by the admin, you cannot save edits to the name and header photo	Fixed and checked the edit function on the header page so that it can save all edits
8.	The majority of input titles or names and captions can still store data that is less or more than the specified test condition limits	Provides a function to validate the input limit for the title or name and caption
9.	When uploading files, they can still be filled in in the doc input format and do not comply with the specified test condition limits.	Provide information if it can only accept files and photos with a certain format and size, but it is better to make it able to upload in many formats

Table 1 shows the weaknesses found in terms of functionality and performance after testing and recommendations for necessary improvements.

Repair Design
After knowing the weaknesses of the system and providing recommendations for improvement, an improvement plan is then created from the recommended improvements.
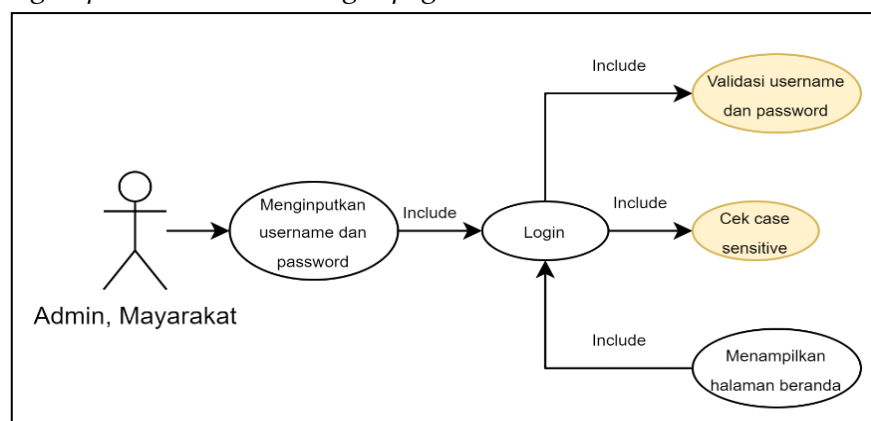1. *Designing improvements to the login page*

Figure 2. Use Case Diagram for Login Page Improvements

Figure 2 is a use case diagram for improvements to the login page. The user enters a username and password. Then on the login page, a case-sensitive check and input validation will be carried out. If the login input is correct, the user can continue to the home page.
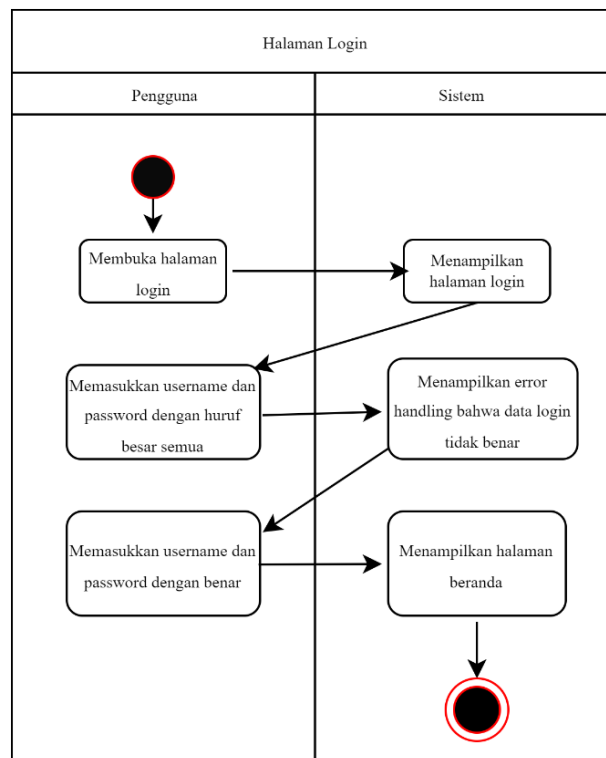
Figure 3. Activity Diagram for Login Page Improvements

Figure 3 is an activity diagram that describes the improvement plan for the system on the login page. Before testing, if you enter the username and password using capital letters, the system can still save the data and continue to the home page. Therefore, additional case-sensitive functions are needed so that if the input is wrong it can display error handling that the input is wrong and cannot continue to the next page.
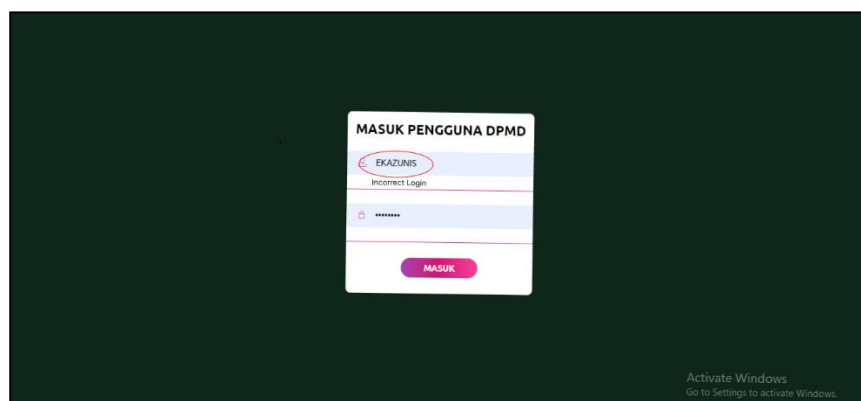

Figure 4. Example of the Login Page Improvement Display

Figure 4 is an example of the improvement display after being given a case-sensitive function so that if you enter the username and password using all capital letters, the system can no longer continue to the next page and a handling error appears that the login process is not correct.

2. *Designing Article Update Improvements*
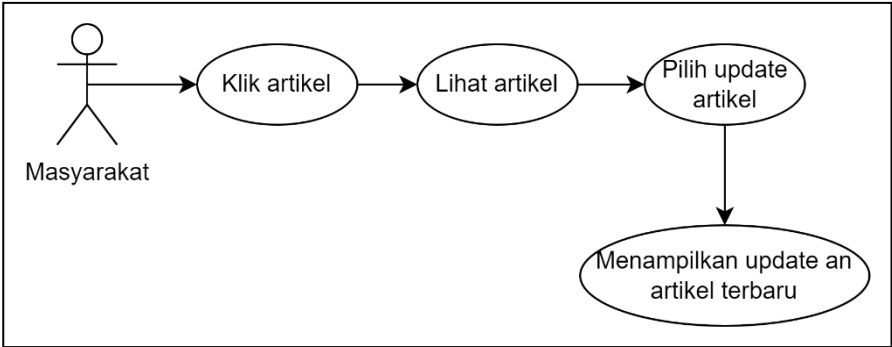
Figure 5. Use Case Diagram for Improvement of Article Update Page

Figure 5 is a use case diagram for improvements from the article update page. The user clicks on the article, then the user can see the list of articles and select update article. If the user clicks update article, the user can see the article that has been updated according to the update date.
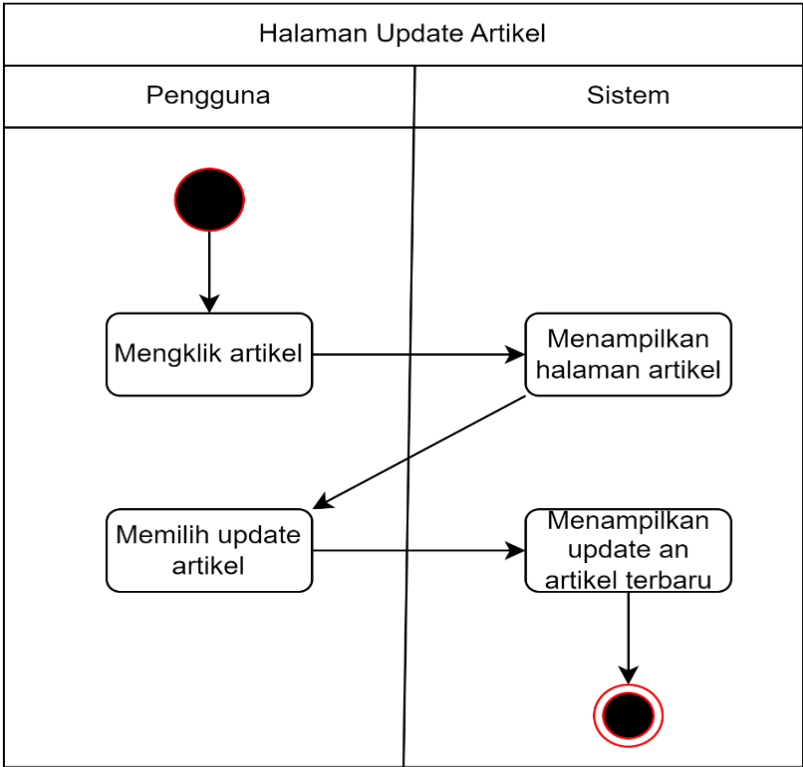

Figure 6. Activity Diagram for Article Update Page Improvements

In Figure 6, there is an activity diagram that depicts the system improvement plan on the article update page that is accessed by the public. Previously, the article page accessed by the public could not display updates and the latest articles. Therefore, it must be repaired so that updates and the latest articles can be displayed.

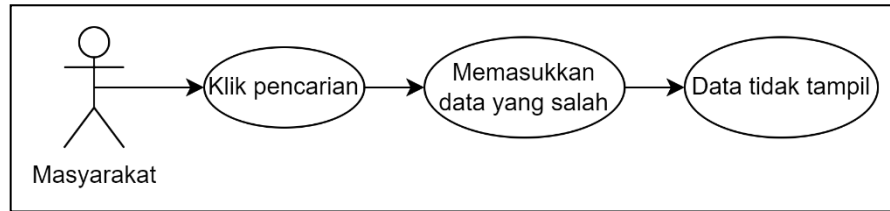3. *Designing page corrections for articles, photos, videos, documents searching for incorrect values*

Figure 7. Use Case Diagram for Repairing Pages for Articles, Photos, Videos, Documents Searching for Wrong Values

Figure 7 is a use case diagram for repairing article pages, photo pages, video pages and document pages for searching for incorrect values. The user clicks search. If the user enters incorrect data, the system will not display any data.
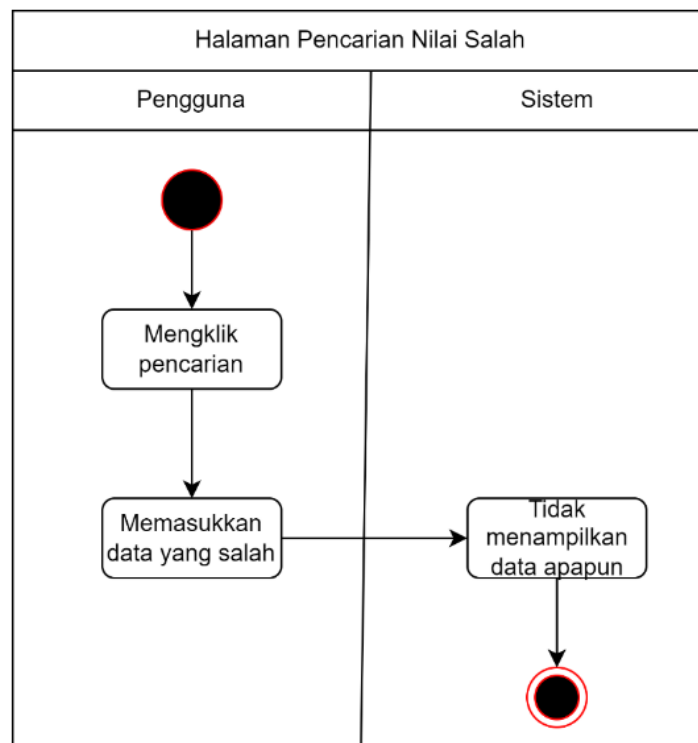

Figure 8. Correction of Article Pages, Photos, Videos, Search Documents with Wrong Values

In Figure 8, there is an activity diagram that depicts the improvement plan for the system on the article search page, photo page, video page and document page. Before testing, if you enter incorrect data in a search, the system still displays the entire data. Therefore, the search function must be corrected so that when you search with an incorrect value, no data is found.
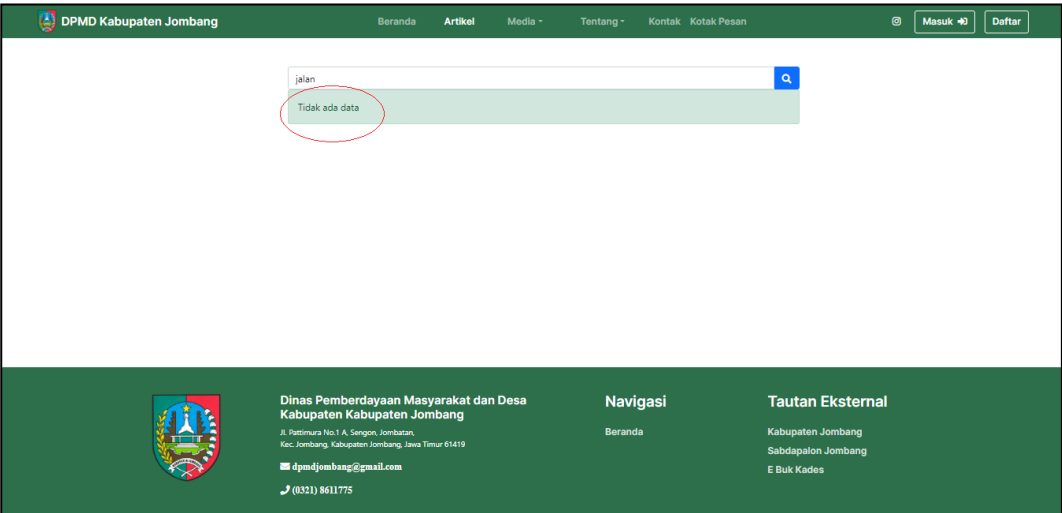
Figure 9. Example of page correction display for articles, photos, videos, documents, search for incorrect values

Figure 9 is an example of a repair display for a search page with an incorrect value. After fixing the search function section, if data is entered with incorrect values, the system no longer displays all the data and a message appears that the data does not exist or the data was not found.

4. *Page Improvement Design Manage Headers, Articles, Photos, Videos, Documents, Wrong Value Search Fields*
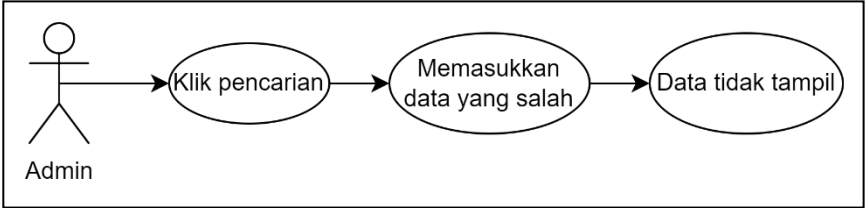

Figure 10. Use Case Diagram Page Improvements Manage Headers, Articles, Photos, Videos, Documents, Search Fields Wrong Values

Figure 10 shows a use case diagram for improvements to the header management page, article management page, photo management page, video management page, document management page, and incorrect value search field management page. Admin clicks search. If the admin enters incorrect data, the system will not display any data.
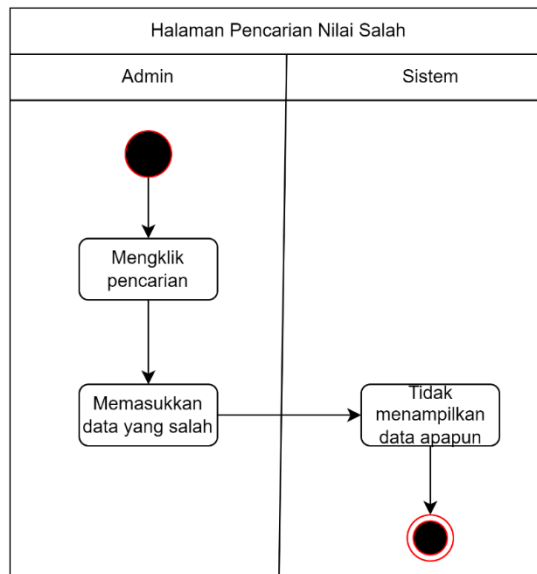
Figure 11. Activity Diagram Page Improvements Manage Headers, Articles, Photos, Videos, Documents, Search Fields Wrong Value

In Figure 11, there is an activity diagram that illustrates the improvement plan for the system on the header management page, article management page, photo management page, video management page, document management page, and incorrect value search field management page. Before testing, if you enter incorrect data in a search, the system still displays the entire data. Therefore, the search function must be corrected so that when you search with an incorrect value, no data is found.
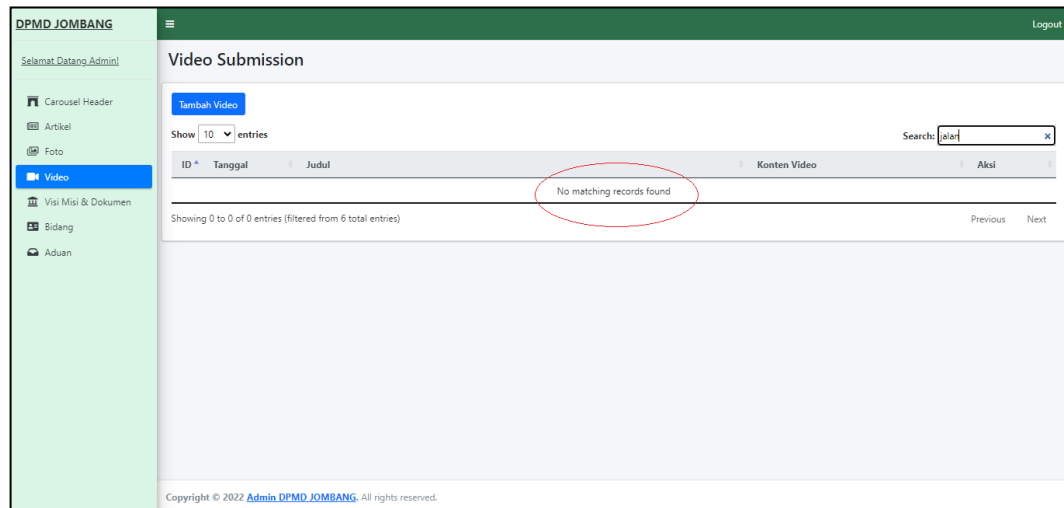

Figure 12. Example of Page Repair Display Manage Headers, Articles, Photos, Videos, Documents, Search Field Wrong Value

Figure 12 is an example of a repair display for a search page with an incorrect value. After fixing the search function section, if data is entered with incorrect values, the system no longer displays all the data and a message appears that the data was not found or no matching records were found.

5. *Designing improvements to the Manage Photos, Documents, Date Fields page which is not updated*
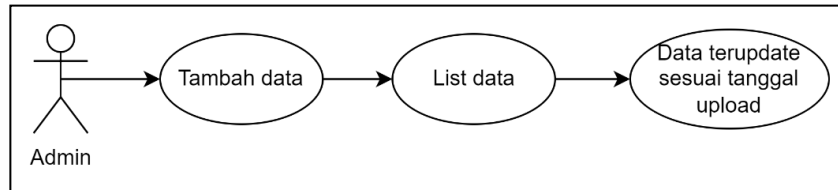

Figure 13. Use Case Diagram Repair Page Manage Photos, Documents, Date Fields Not Updated

Figure 13 shows a use case diagram for improvements to the photo management page, document management page, and date field management page which is not updated. Admin adds new data. After adding new data, the admin can see the data list and update data according to the upload date.
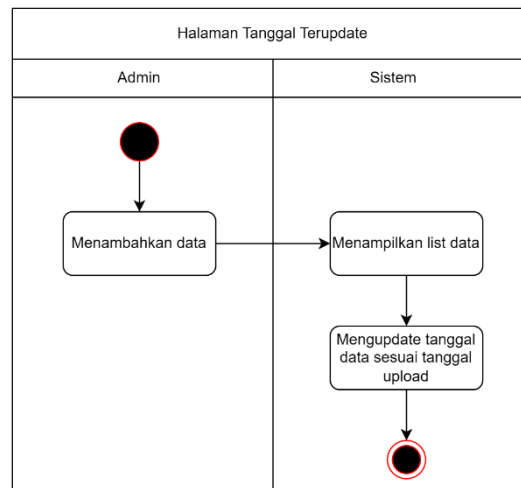

Figure 14. Activity Diagram Repair Page Manage Photos, Documents, Date Fields Not Updated

Figure 14 is an activity diagram that illustrates the system improvement plan on the photo management page, document management page and non-updated date field management page. Before testing, if you enter new data, the date cannot be updated according to the date the data was uploaded. Therefore, the date section must be corrected so that it can be updated according to the upload date of photos, documents and fields.
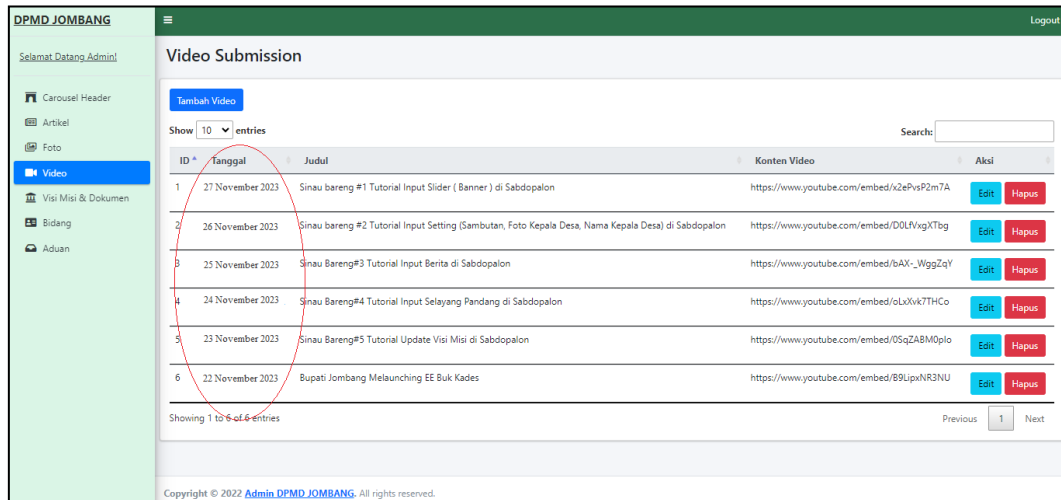
Figure 15. Example of a repair display for the Manage Photos,
Documents, Date Fields page which is not updated

Figure 15 is an example of a page repair display where the date is not updated. Once corrected, the dates will be sequential and updated according to the upload date of the photo, document or field.

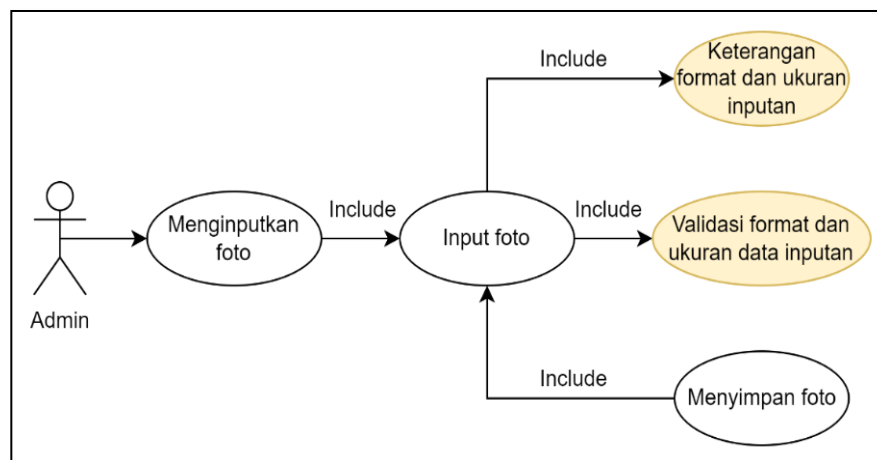6. *Designing Photo Input Improvements*

Figure 16. Use Case Diagram for Photo Input Page Improvements

Figure 16 is a use case diagram for improvements to the photo input page. Admin inputs photos according to the specified format and size. If the format and size comply with the provisions, the data will be saved.
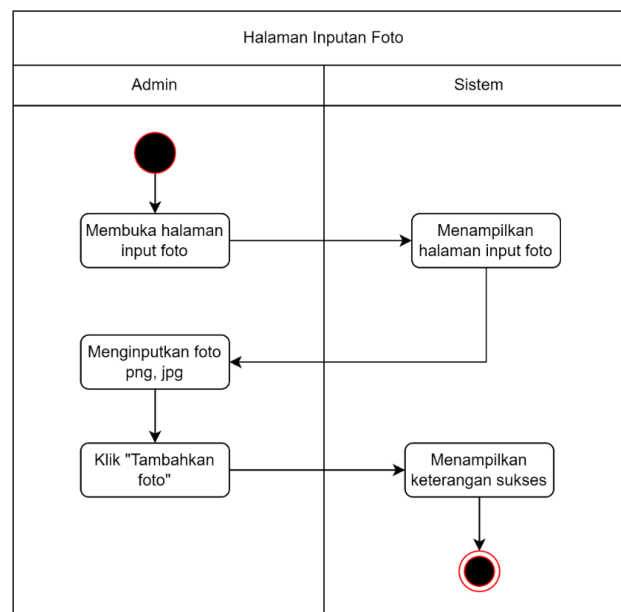
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Figure 17. Activity Diagram for Photo Input Page Improvements

Figure 17 is an activity diagram that describes the improvement plan for the system on the photo input page. Before the test is carried out, uploaded photos can still be input with photos in jpeg format and do not comply with the test condition limits set by the agency. Under these provisions, you should only be able to upload photos in jpg and png format. In addition, the upload on the photo input page has been changed to allow uploading photos in many formats and adding information so that users know what formats can be uploaded. On this page, a maximum photo size limit is also added so that users do not just enter large amounts of data because it will result in a time-out.
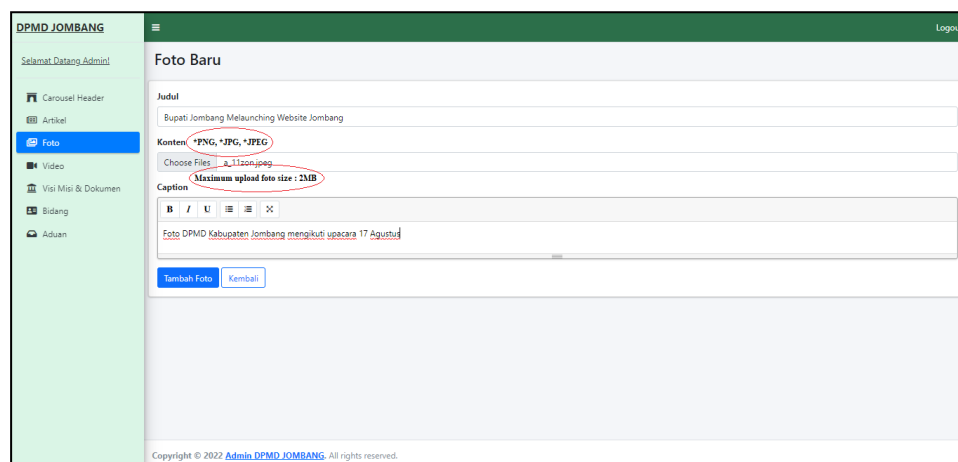

Figure 18. Example of Photo Input Page Improvement Display

Figure 18 is an example of the display of improvements to the photo upload page on the photo input page. In the section circled in red, a description of the format and the maximum limit of the uploaded photo file is given so that users know what formats can be uploaded and the maximum limit of photos so that users do not just enter large amounts of data because it will result in a time out.

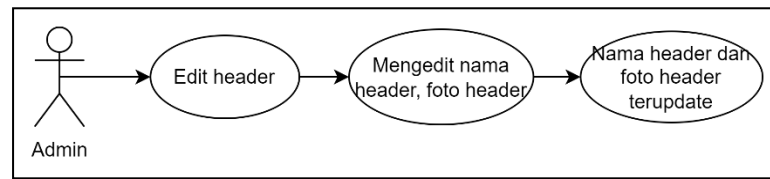7. *Planning Improvements Edit Page Manage Header*

Figure 19. Use Case Diagram Improvement Edit Manage Header Page

Figure 19 is a use case diagram for improvements to editing the header management page. Admin clicks edit header. Then edit the header name and header photo. After that, the header name and header photo are updated.
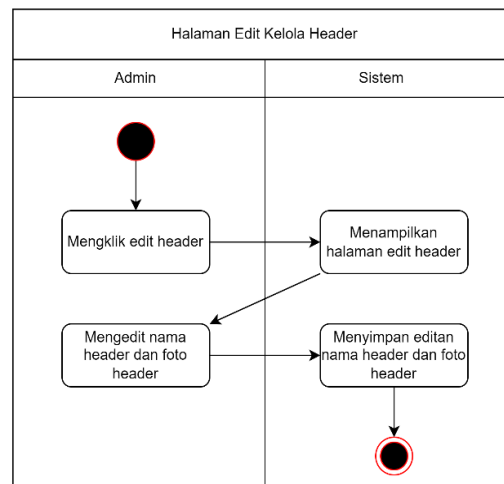
Figure 20. Activity Diagram Improvement Edit Manage Header Page

Figure 20 is an activity diagram that illustrates the system improvement plan on the edit manage header page. Before testing, the edit manage header page could not save edits to the header name and header photo. Therefore, improvements must be made and the edit function so that the header management edit page can save all edits.

8. *Designing Form Improvements with Limits for Inputting Titles or Names and Captions*

Figure 21. Use Case Diagram for Form Improvement with Title or Name and Caption Input Limits

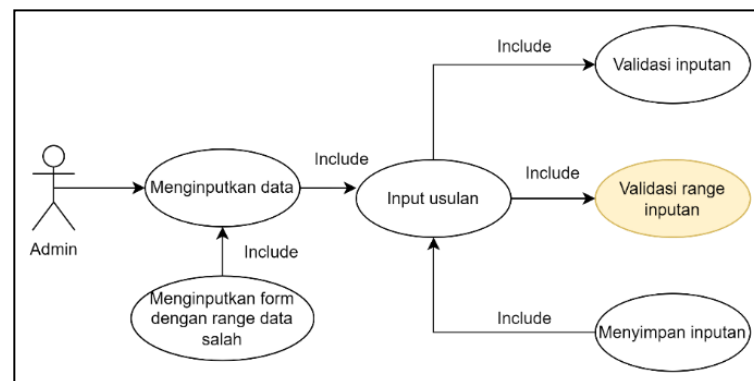In Figure 21, there is a use case diagram for improving the form with limits for inputting titles or names and captions. Admin inputting data is like entering a form with the wrong data range. If the data range entered is incorrect, then the system will not be able to save the data.
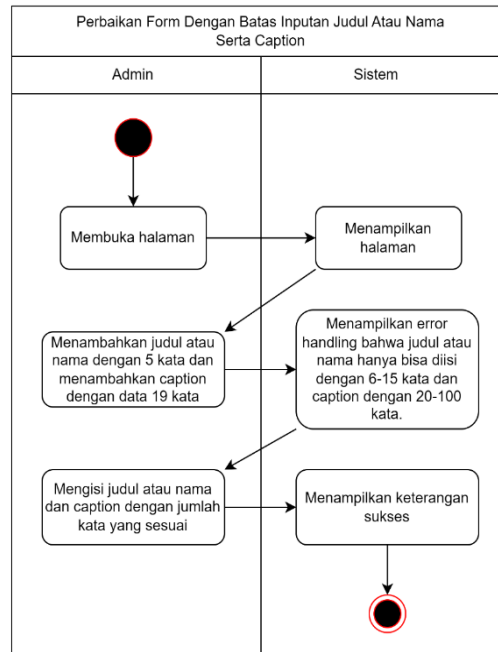
Figure 22. Activity Diagram for Form Improvement with Title or Name and Caption Input Limits

Figure 22 is an activity diagram for improving the form with limits for inputting titles or names and captions. Before testing, the majority of input titles or names and captions can still store data that is less or more than the specified test condition limits. Therefore, a validation function has been added so that if the input data is more or less than the limit value, the system cannot save the data and a handling error appears that the input does not match the limit value for the title or name and caption.

Figure 23. Example of Form Improvement Display with Title or Name and Caption Input Limits

Figure 23 is an example of a form improvement display with limits for inputting the title or name and caption on the add photo page. Before testing, the input title or name and caption can still be filled in even if the input data exceeds or is less than the specified limit value. Therefore, it needs to be improved by adding a validation function so that if the input data is more or less than the limit value, the system cannot save the data and a handling error appears that the input has a limited number of words.

9. *Designing Document File Input Improvements*
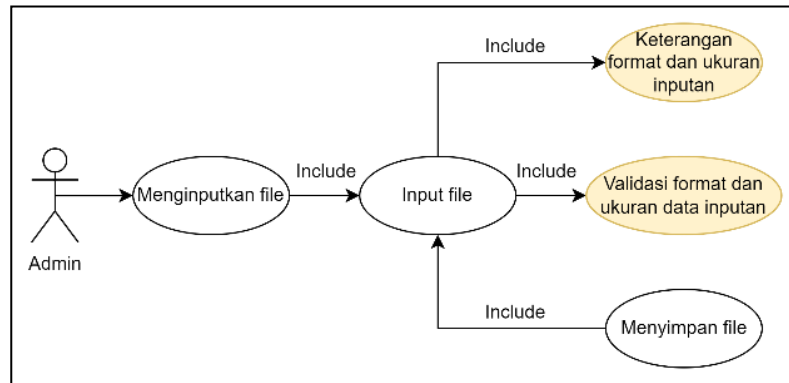
Figure 24. Use Case Diagram for Document File Input Page Improvements

Figure 24 is a use case diagram for improvements to the document file input page. Admin inputs files according to the specified format and size. If the format and size comply with the provisions, the data will be saved.
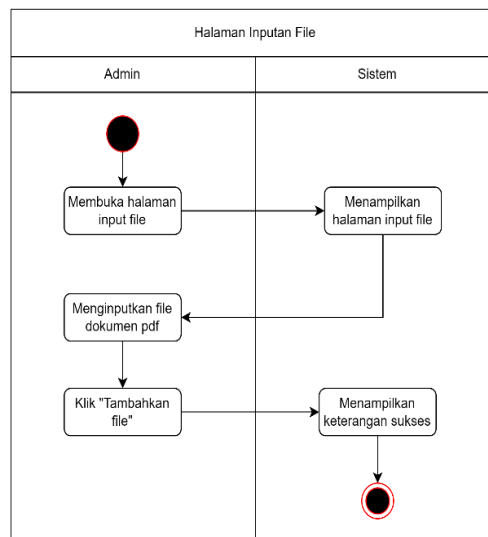
Figure 25. Activity Diagram for Document File Input Page Repair

Figure 25 is an activity diagram that describes the improvement plan for the system on the document file input page. Before testing is carried out, file uploads can still be input with document files in doc format and do not comply with the test condition limits set by the agency. Under these provisions, you should only be able to upload files in PDF format. In addition, the upload on the file input page was changed to allow uploading files in many formats and added

information so that users know what formats can be uploaded. On this page, a maximum file limit is also added so that users do not just enter large amounts of data because it will result in a time-out.

Figure 26. Example of the File Input Page Improvement Display

Figure 26 is an example of the appearance of improvements to the file upload page on the vision, mission and document page. Before testing is carried out, file uploads can still be input with document files in doc format and do not comply with the test condition limits set by the agency. Under these provisions, you should only be able to upload files in PDF format. In addition, the upload on the file input page was changed to allow uploading files in many formats and added information so that users know what formats can be uploaded. On this page, a maximum file limit is also added so that users do not just enter large amounts of data because it will result in a time-out.

CONCLUSIONS AND RECOMMENDATIONS

Testing of the community service information system of the Jombang Regency Community and Village Empowerment Service at the Jombang Regency Community and Village Empowerment Service has been successfully carried out using Black Box Testing with a combination of Boundary Value Analysis and Cause Effect Graph techniques. Based on the results of testing the public service information system testing of the Jombang Regency Community and Village Empowerment Service at the Jombang Regency Community and Village Empowerment Service, several conclusions can be made as follows:

1. Testing by combining Boundary Value Analysis and Cause Effect Graph techniques can help in finding errors in the system through the stages of identifying causes and effects from existing specifications using the Cause Effect Graph. Cause is an input condition and effect is the result of the input condition or is called an output condition. Then we will depict cause-and-effect relationships, convert images into decision tables, determine limit and upper values for an input using Boundary Value Analysis, determine the test data used, and create test cases.

2. Combining Boundary Value Analysis and Cuse Effect Graph techniques can help find various errors in the public service information system of the Jombang Regency Community and Village Empowerment Service, such as errors from the absence of sensitive cases, lack of data validation, mismatches in uploaded file formats and the performance of applications that cannot be run in certain browsers. Combining these two techniques makes it easier to test systems that have a large number of test cases and complex features, so combining these two techniques can be more practical in testing. The use of the Cause Effect Graph in the community service information system of the Jombang Regency Community and Village Empowerment Service is more dominant for testing data entry features, and features in the form of buttons. Meanwhile, Boundary Value Analysis is more dominant in testing features that have a range such as name or title input, caption input, and complaint message input.

3. The results of research and testing on the community service information system of the Jombang Regency Community and Village Empowerment Service at Jombang Regency Community and Village Empowerment Service obtained an effectiveness value of 77.86% which is quite effective and still needs to be repaired and developed to achieve maximum effectiveness value so that functionality runs more optimally.

From the results of testing the community service information system of the Jombang Regency Community and Village Empowerment Service using Black Box Testing with a combination of Boundary Value Analysis and Cause Effect Graph techniques, the author provides suggestions as the next step in developing the community service information system of the Jombang Regency Community and Village Empowerment Service, namely:

a) It is hoped that further development of the Jombang Regency DPMD community service information system can improve inappropriate functions such as adding case sensitivity to the login form so that program security is maintained.

b) Improved several functions such as article updates, search functions, date updates, and several editing functions so that they can run properly and appropriately. Add error handling to clarify input that is not appropriate, add validation of input data to the program so that the data entered is as desired, provide a function to validate input limits for titles or names and captions, provide information if it can only accept files or photos with the format and a certain size, as well as creating a system that can be run in all browsers, making it easier for users to access.

FURTHER STUDY

This research still has limitations, so further research needs to be carried out regarding the topic "Black Box Testing in Community Service Systems Using Boundary Value Analysis and Cause Effect Graph Methods" to provide additional information for readers.

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