An information management system for effective disaster relief operations

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Abstract. During an emergency situation, there is often confusion in information that can complicate disaster management efforts. For this reason, it is necessary to design an information system that can support emergency response operations. The purpose of designing this information system is to design a disaster management information system to strengthen emergency response operations quickly, precisely, and dynamically, and can be a decision supporter to facilitate emergency response operations. The system was developed using the waterfall method using the Object-Oriented Programming (OOP) approach. The design of information systems uses the PHP programming language and uses MySQL as a database. Then the system that has been designed is verified and validated using the Black Box method. The results of the information system design can provide dynamically needed information so that it can assist in scheduling and allocating volunteers, verifying data from donors, making TRC reports, collecting data and refugee needs, and estimating the distance between posts and evacuation sites.

1. Introduction

Disaster refers to an extraordinary event that has a detrimental effect on humans and ecosystems. Disaster response operations should be conducted promptly after the event to minimize human loss and misery, to speed up the rehabilitation and recovery process of the victims, and to minimize economic losses. Late response and wrong decisions made in the operations by disaster emergency managers may risk a victim’s life or increasing their suffering.

Disaster response operations are complicated and are information-intensive as these involve many parties. A huge quantity of data has to be collected, processed and submitted including data of volunteers, donors, victims, aid supplies, equipment, and vehicles [1]. Both information and coordination are important factors to ensure that the humanitarian response operations can be conducted efficiently and effectively [2]. Accurate and timely information as well as better coordination among activities are very helpful to decision-makers for providing a rapid response [3]. Altay et al. [2] states that the acknowledgment of the important role information management in establishing effective
emergency response, coordination, and decision making have increased. Moreover, [4,5,6,7] underlined the significance of disaster management information system for improving effectiveness and efficiency of relief response operations.

Disaster management information systems (DMIS) is a computer database that facilitates many actors to share and use real-time information during a response period. Sakurai et al. [8] and Krumay et al. [1] identified that the information system in disaster management is used for coordinating activities, processing information, and communicating with other disaster stakeholders. Many studies on DMIS have conducted in different countries and grown significantly since 2004 [9]. It is not possible to design a system that is suitable for all countries and all disasters [4].

Lakovou [10] proposed an information management system for a hurricane (IMASH) that is designed specifically for hurricane disaster comprising preparedness and post-disaster restoration activities. Lanka software foundation has developed Sahana used the aftermath of the 2004 Asian Tsunami and 2005 Pakistan earthquake to trace missing persons, coordinate donor organizations in distributing relief supplies, and recording locations of refugee camps. The software encompasses a database of victims and their states, donors and their activities, volunteers and their activities. In facing disruptive events that will happen, proactive planning could be prepared so that the disasters will cope with effectively and efficiently [11]. Inan et al. [12] proposed a knowledge system for disaster management with a case study of the volcano eruption in Indonesia. Hu et al. [13] developed an integrated model that explores the use of information, communication, and technologies (ICT) to improve community resilience toward disasters. It covers all phases in disaster management: mitigation, preparedness, response, and recovery. The developed models show the technologies used to support each disaster phase while the required data and flow of information are not clearly explained. Rafi et al. [9] compared design approaches applied in the DMIS. They recommended a maximum of five modules including in the DMIS, which are inventory, mitigation, administrative control, response and recovery, and communication infrastructure module.

In time, people heard disaster attacks one area and cause of many victims, and aids will be delivered either in material or immaterial to an affected area spontaneously. Aid supplies may receive are not appropriate either in quantities or types. Besides, volunteers who come to disaster areas at one time are also possible out of expectation in terms of number or specialization. Later, this situation is the potential to create a problem for the area. Not enough supplies will make unfulfilled and unsatisfaction demand. More volunteers will become a burden to the area since they need food and shelter as victims do. Thus, both donors and volunteers are supposed to communicate with the disaster area before submitting their aids to avoid shortage or redundancy. This situation has not considered in the previous studies yet.

This study is aimed to design a disaster management information system for supporting response operations. The developed system will show how data of victims, donors and volunteers are collected, integrated, and used in decision making as well as the information flow and exchange among multiple stakeholders for performing an efficient and effective response operation. Besides, the system also provides decision-making processes covering allocation both aid supplies and volunteers. Then, the developed DMIS can support disaster coordinator in performing efficient and effective emergency response operations.

2. Methods
The method used in designing this management information system is the waterfall method, which consists of four stages, including the stages of analysis, design, coding, and testing. The stages of designing this management information system include system requirements analysis consisting of two processes [14]:

1. Object-Oriented Analysis (OOA)

   Information system design is carried out in the Object-Oriented Analysis (OOA) stage, which is designing business processes from existing systems, then determining the parties involved in the system (users), designing use case diagrams, and designing use case descriptions.

2. Object-Oriented Design (OOD)

   The second stage in the Unified Modelling Language (UML) is Object-Oriented Design (OOD). OOD describes the form of a system based on the results of Object-Oriented Analysis (OOA). OOD is designed by making a diagram that shows the design of the information system created. Diagrams used at this stage include activity diagrams, sequence diagrams, class diagrams, and Entity Relationship Diagrams (ERD). The system design described using the Unified Modelling Language.

Furthermore the coding is done and followed by testing by the verification and validation process.

3. Results and discussion

3.1. Object-Oriented Analysis (OOA)

   In this stage is design the business processes diagram from the existing systems, then determine the parties involved in the system (users), last design the use case diagrams and the use case descriptions.

3.1.1 Business process diagram. Business Process describes all activities that occur in the system as a whole and how the flow of information that occurs in the system [15]. In Figure 1 shows the business process designed explains the flow of information during the emergency response operation after a disaster occurs. The business process designed involves several parties, including volunteers, donors, Rapid reaction teams, command post commanders, and field coordinators who are at the evacuation site.

   Shortly after the disaster occurred, the Rapid reaction teams will go to the disaster location to conduct a rapid assessment relating to the impact of the event, which includes the location of the disaster, the number of victims, and damage to facilities and infrastructure. Then, the result will be an input in determining a disaster scale and what will do next.

   Relating to disaster relief aids, data obtained from rapid assessment regarding evacuee and relief prepositioning stocks data will be used as a reference to determine the number and type of relief aids as well as the number and specialization of volunteers required by the disaster victims. Then this information will be informed to the donors and volunteers who come to the disaster area are appropriate with the demand. Moreover, the information is also used for making the initial emergency response operation plan including allocation and distribution of aid supplies and volunteers to affected areas.

   Meanwhile, disaster victims will be evacuated to shelters. The field coordinators will record evacuee data including number, gender, age, and their conditions then submit the data to the command post. The
data must be updated every day since there is a possibility that the disaster victims will come in or left the camp. The data are needed in allocating volunteers and relief aids among refugee camps.

Most of the time, there is no enough relief prepositioning stock for distributing to disaster victims. The disaster coordinator is required to inform the donor regarding the shortage encompassing the type and amount of relief supplies needed by affected people. Otherwise, the donors are also required to communicate supplies that they will send to the disaster area previously to avoid shortage or redundancy. Then, all aid supplies that come to the affected area from the donors are appropriate items and can meet the disaster victim demand. Moreover, the information relating volunteers needed such as number and specialization of volunteers and when they will come and how long they will be in the disaster, is also necessary. It will ensure that the volunteers who came are the people required in the disaster areas. Otherwise, they will only add burden to the areas since they require food and shelter as the disaster victims do while its availabilities are limited. Furthermore, the results of this rapid assessment reported to the disaster coordinator. Data obtained from the Rapid reaction team are used as a reference for the initial disaster needs.

Furthermore, after the closure of the emergency response operation period, the disaster coordinator is needed to make a report regarding all daily activities performed during the period.

![Figure 1. Business process diagram](image)

3.1.2 Actor identifications. Actors or users are all things outside the system that will be involved in activities in the system. Actors can be people or objects involved and have a role in the success of operations in the system. The Actor that is involved in this information system of emergency response operations are:
a. Command posts act as the super admin who has the task in managing every data and information that enters the information system.

b. Volunteers act as users in the process of collecting data from volunteers. The information is used by the command post in collecting and allocation of volunteers according to their specialization and qualifications that are needed in the emergency response process.

c. Donors act as users in data collection in emergency response operations. The information and type of help from the donors used to help the needs of refugees in refugee camps.

d. Rapid reaction team as one of the users plays a role at the beginning of the information flow in the emergency response information system.

e. Evacuation officer, one of the users that play a role in collecting data and sending requests for refugee needs to the command post

3.1.3 Use case diagram. Use case diagram is an illustration of the interaction between actors and systems or the interaction between a system and other systems. Use case diagrams consist of diagrams for use cases and actors. Use case diagrams represent people who will run or people who interact with the application system. Each use case consists of one or more scenarios that explain how the system interacts with other users or systems to achieve a particular goal. Figure 2 shows the use case diagram, which involves five actors and 11 use cases.

3.1.4 Use case description. Use case description is a description of a use case that describes information related to the interaction between input from the actor and the response from the system to a use case. The description of each use case in the use case diagram explained in the form of actions and reactions of the system designed. The use case description that describes are disaster condition report, volunteer data collection, donors data collection, volunteer allocation, help allocation, volunteer data, donors data, refugee data collection, help request, login, handling different types of users.
3.2. Object-Oriented Design (OOD)

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3.2.1. Activity diagram. Activity diagrams are design based on the basic flow and alternative flow in a use case diagram scenario. Activity diagrams describe the interaction between actors in use case diagrams with systems and sequence of activities used to explain the activities of an operation.

3.2.2. Sequence diagrams. Sequence diagrams describe the relationship or interaction between objects in the system in the form of a message that described against time. Ordinary sequence diagrams described a series of steps taken in response to an event to produce a specific output.

3.2.3. Class diagrams. Class is a set of similar objects that have properties (attributes), general behavior (operations), and general relations with other objects. Class diagrams based on use case diagrams and activity diagrams. Class diagrams can describe the classes used in the information. Figure 3 shows the class diagram.
3.2.4. Entity Relationship Diagrams (ERD). Entity Relationship Diagram (ERD) is a technique used in modeling data requirements of an organization. ERD used in information system design to prevent duplication of data in the database table. Entity Relationship Diagrams used in the design of emergency response operations management information systems directly generated from the previously designed class diagram design. Therefore, the attributes used in the database are the same as those in the class diagram. Figure 4 illustrates the ERD for the system.

3.3. Coding

Emergency response management information systems were designed using the PHP programming language, which is a web-based programming language through Sublime Text software, and uses databases to store data.

3.4. Testing

The testing phase on system applications is done through a process of verification and validation. Verification and validation are conducted to assess whether the application or program designed meets business requirements and technical requirements according to the work function as desired. The verification process in this study carried out using the Black Box Testing method. Black box testing is an application testing or program carried out to find out whether the application designed can run well as expected or not. This test observed the results of the execution by testing the data and checking the functionality of the application.

The application was designed with the PHP programming language to make it easier for users with web views. The application designed can be accessed from various devices and does not need to install the application first. This emergency response management information system was managed by a super admin who is the BPBD of Padang City.

The functions contained in the application design consist of functions of creating, editing, deleting, and displaying data. The function makes it available when the volunteer user and donor add data to the system. The editing function is in the super admin, where the super admin can change and manage data. The delete function is also found in the super admin and admin at the evacuation location.

The amount of incoming and outgoing data can confuse the admin in managing data. In facilitating the admin managing data, the data is presented in various types of graphics or dashboards, and the dashboard displayed as needed. The data contained in the graph is obtained from the database so that the graphic form can change according to changes in the data flow in the database.

The design of an information management system for emergency response operations is intended for volunteer users, donors, rapid reaction teams, refugee officers, and main posts. Volunteers who wish to participate in emergency response operations must first register in the system, and this aims to facilitate the post office in allocating volunteers. Volunteers can also monitor the status of volunteers, such as the approved status of volunteers and the location of volunteers. Data collection and allocation activities also aim to avoid the inequality of the number of volunteers in a location.

The advantages contained in the disaster management information system application in this emergency response process include:
1. Good Data Management
2. A Dashboard to Support Decision Making
3. Data Updated Real-Time
4. Applications that are designed to be dynamic
5. General Applications

The shortcomings of the disaster management information system application in this emergency response process, as follows:
1. Not integrated with the BNPB and BPBD websites.
2. Not Including All Disaster Processes
3. The Capacity of the Truck Is Still General
4. Scheduling Volunteers Still Static

4. Conclusion and future work

Based on the results of the design of the disaster management information system for emergency response operations, it was concluded that the information system designed could assist in emergency response operations. The system designed includes being able to help command post commanders in making decisions based on the data displayed on the dashboard contained in the system. The data displayed by the dashboard comes from data that is updated in real-time, so command post commanders can see and make decisions accurately.

The information system designed does not only make it easier for command post commanders to manage data and information, but also facilitates refugee officers in managing refugee data and managing demand data. Besides, the information system designed also facilitates the Rapid Reaction
Figure 3. Class diagram
Figure 4. Entity relationship diagram
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