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Prototype of Mobile Reverse Logistic Application for Managing Important Document of Natural Disaster Victims (Case Study : The Eruption of Mount Merapi Disaster)

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Abstract

Disaster management is one of the activities done to reduce losses from natural disasters. Important document is one of the valuable assets owned by the people. A system of document storage services is needed to reduce such losses. The concept of reverse logistics is an appropriate method to be applied in this case, because the flows of goods come from the consumers to the warehouses. Besides deposited, certain important documents such as vehicle certificate and land certificate can also be pawned to obtain loan. To manage the storage processing and documents pawning, it is necessary to build an appropriate application to this case. Smartphone-based mobile applicationis quite fit because the situation at the disaster site is very limited. The application built is a smart client application thatcan access datafrom the server via webservice. The webservice is built with REST architecture and JSON message format to exchange data between server and client, while Android is selectedas the client's device.

Keywords: *mobile applications, important documents, reverse logistics, web service*

1. Introduction

Natural disasters eruption of Mount Merapi in late 2010 caused great damage and loss. One of the disadvantages includes a loss of important documents such as certificates of land, insurance letters, birth certificates, vehicle registration, and so forth. The lost of these important documents would cause a loss of cost, time, and effort.The government needs to build an essential document management system. The system is useful for managing the citizen's documents while they are located in refugee camps or until the disaster status declared safe. The system is built using the concept of reverse logistics for the flow of goods from the refugees (point of consumption) which is then transported and stored in a secure storage area (point of origin).

Research on disaster management system and reverse logistics has been done a lot, including the design of disaster logistics (Oktarina, 2009), hierarchical modeling approach for relief logistics network design (Kusumastuti&Wibowo, research on reverse logistics network design of household appliances based on green logistics (Zhou and Zhang, 2009), role of information technology and collaboration in reverse logistics supply chains (Jayaraman, 2008) and others.

However, no previous researches discuss the application with the concept of reverse logistics for disaster relief, so the research on this issue is wide opened.

The rapid development of information technology, especially mobile devices such as Smartphone, strongly supports the utilization of these technologies for the benefit of mankind. Android as a new mobile platform, just got the attention of the world, show significant growth in the market of mobile users.

For that reason, Andoid-based mobile applications is a solution that can be applied to solve the problem of handling victim's important documents of Mount Merapi disaster. With this system, the victims can store or pawn their important documents. This system will be managed by the government in collaboration with financial institutions such as pawnshop or bank.

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2. Research Method

2.1 Data Collection

Data collection stage is done by searching the literature on reverse logistics, smart client, web service, Android, and so forth. At this stage the data collected as required, the amount of losses caused by disaster, the map location of the disaster, the radius of the disaster, the location of warehouses and refugee camps, all kinds of documents can be stored and other information.

2.2 Analysis and Design

1. Determine the business processes include transaction processing for document savings and pawning.
2. Determine the system requirements in accordance with the business process in reverse logistics systems.
3. Create a map of the location and logistics channels on digital maps by marking each location on the map and record the distance between sites, and then create a connected weighted graph based on the mapping results.
4. Create a model to find the shortest path between refugee camps and warehouse using Dijkstra's algorithm.
5. Create a system modeling in the form of UML diagrams such as Use Case Diagram, Activity Diagram, Sequence Diagram, Class Diagram, Component Diagram, and Deployment Diagram.
6. Create a database design in the form of ERD (Entity Relationship Diagram).
7. Create user interfacedesign to provide an overview interfaces that will be implemented on the system.

2.3 Implementation

1. Create a database based on database design that was created earlier.
2. Create program codes based on the designs that have been made at the previous stage, thus forming a prototype application that can be used.
3. Perform debugging to find errors in the program for repair.

3. Reverse Logic

Reverse logisticsis the opposite of the normal logistic process. Logistics has been defined as that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements.Reverse logistics has been defined as the movement of product or materials in the opposite direction for the purpose of creating or recapturing value, or for proper disposal (Tibben-Lembkeand Rogers, 2002).

Table 1. Differencesin Forward and Reverse Logistics

Forward Logistic	Reverse Logistic
Forecasting relatively straightforward	Forecasting more difficult
One to many transportation	Many to one transportation
Product quality uniform	Product quality not uniform
Product packaging uniform	Product packaging often damaged
Destination/routing clear	Destination/routing unclear
Standardized channel	Exception driven
Disposition options clear	Disposition not clear
Importance of speed recognized	Speed often not considered a priority
Forward distribution costs closely monitored by accounting systems	Reverse costs less directly visible
Inventory management consistent	Inventory management not consistent
Product lifecycle manageable	Product lifecycle issues more complex
Marketing methods well-known	Marketing complicated by several factors

Reverse logistics process that are manage defficiently and effectively potentially obtaine conomic value and enhance the positive image ofcompanies.

4. Shortest Path Algorithm

In graph theory, the **shortest path problem** is the problem of finding a path between two vertices (or nodes) in a graph such that the sum of the weights of its constituent edges is minimized. An example is finding the quickest way to get from one location to another on a road map; in this case, the vertices represent locations and the edges represent segments of road and are weighted by the time needed to travel that segment (Rosen, 1998).

Dijkstra's algorithmis a graph search algorithm that solves the single-source shortest path problem for a graph with nonnegative edge path costs, producing a shortest path tree. This algorithm is often used in routing and as a subroutine in other graph algorithms (Rosen, 1998).

For a given source vertex (node) in the graph, the algorithm finds the path with lowest cost (i.e. the shortest path) between that vertex and every other vertex. It can also be used for finding costs of shortest paths from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined. For example, if the vertices of the graph represent cities and edge path costs represent driving distances between pairs of cities connected by a direct road, Dijkstra's algorithm can be used to find the shortest route between one city and all other cities.

5. Mobile Client Applications

A. Smart Client

A smart mobile client refers to mobile application software designed for smart mobile devices. It uses local computing processors and resources to provide certain application functions and services without the support from its application server. A typical example is a downloaded digital game on smart phones. A smart client hasa number of special features listed here (Gao*et al*, 2006):

- It is highly dependent on local resources (e.g., XML Web Services and .NET Framework for Pocket PCs) to support mobile computing processes on mobile devices.
- It supports users with two application operation modes: standalone and off-line.
- It requires mobile client installation and updates on mobile devices through synchronization capability.
- It provides rich mobile user interfaces supporting mobile data with text and multimedia data.

B. Android

Android is a software stack for mobile devices that includes an operating system, middleware and key applications. The Android SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language.Android is a Linux-based operating system for mobile devices such as smartphone and tablet computers. It is developed by the Open Handset Alliance led by Google. It is indeed a comprehensive platform that features a Linux-based operating system stack for managing devices, memory, and processes. Android’s libraries cover telephony, video, graphics, UI programming, and every other aspect of the physical device.

The Android Platform, although built for mobile devices, exhibits the characteristics of a full-featured desktop framework. Google makes this framework available to Java programmers through a software development kit called the Android SDK(Rogers *et al*, 2009).

C. Web Service

A Web service is a software system designed to support interoperable machine-to-machine interaction over a network.

1. REST (Representational State Transfer)

REST defines a set of architectural principles by which you can design Web services that focus on a system's resources, including how resource states are addressed and transferred over HTTP by a wide range of clients written in different languages(Rodriguez, 2008).

A concrete implementation of a REST Web service follows four basicdesign principles:

- Use HTTP methods explicitly.
- Be stateless.
- Expose directory structure-like URIs.
- Transfer XML, JavaScript Object Notation (JSON), or both.

2. JSON (JavaScript Object Notation)

JSON is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language (JSON Team, 2011).

JSON is built on two structures:

- A collection of name/value pairs. In various languages, this is realized as an *object*, record, struct, dictionary, hash table, keyed list, or associative array.
- An ordered list of values. In most languages, this is realized as an *array*, vector, list, or sequence.

6. Reverse Logistic Process

Logistics process includes distribution of goods from one place to another. In the case of reverse logistics, goods will be delivered from the customer to the warehouse. Furthermore, in the relief logistic, we will look for the closest and safest warehouse. It could be that thewarehouse is the closest point from the origin (location of customer), but the warehouse does not allow for storing goods because it is being in the dangerous area. Therefore, other warehouses will be selected to store the goods.

Reverse logistic process for managing important document consist of three transaction/service, that is

1. Document Saving

The documents that can be saved are land certificate, vehicle certificate, insurance document, etc.

2. Document Pawning/Mortgaging

The documentsthat can be pawned are land and vehicle certificate with land or vehicle as the pawning goods / the collateral.

3. Document Returning

Customercantake backthe goods they stored afterpaythe cost of goods’ storage. Customer also can take back the document they pawned after payback the loan they got before.

7. Logistic Network

A. Location Mapping

The logistic network consists of three components, evacuation (refuge) area, warehouse, and path which connect two locations, refuge and warehouse.Evacuation (refuge) is a place where the victims of disaster lived temporary, while the circumstances surrounding the disaster area declared dangerous.Warehouse is storage facilities in a secure location that can be used to store document based on information released by the National Disaster Management Agency (BNPB).

Map of the locationandlogisticsnetworkcreatedbythe disaster sitemapis issuedby theBNPB. And then we made a map of logistic network which connects several refugee camps and nearby warehouse based on these maps. Logistic network modelingis performed usingdigitalmap (Google Map)by markingthe refugee campslocation andthe warehouse location, and thenfindthe distancebetweenthese both locations.

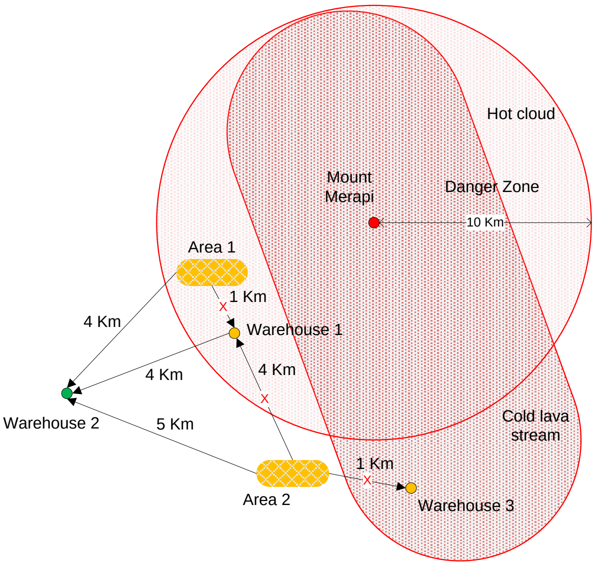


Figure 1. Illustration of Warehouse Choice

B. Network Modeling

Logistics network is thus modeled by a graph consist of:

- Vertex: there are two types of nodes:
  - G represents the point of warehouse
  - P represents the point of evacuation
- Edge: represents the relationship between points/nodes.
- Weight: a weight to each edge connecting two vertices, which represent the distance between two points.

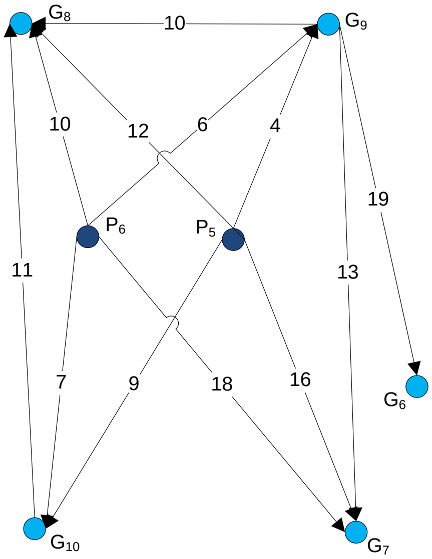


Figure 2. Logistic Network Modeling in The Graph Form

In the warehouse there are parameters that determine whether or not these points are used. In one condition, a storage point cannot be used because it is ona certain status. At the vertex G there are parameters that determine whether or not the vertex is passed. A vertex G cannot be passed if there are certain conditions based on the parameters.

Table 2. Warehouse Parameters

Parameter	**Value**
Status (S)	R (Red/Danger)
	Y (Yellow/Warning)
	G (Green / Safe)
Quota (Q)	F (Full)
	NF (Not Full)

Table 3 shows the availability of the vertex (warehouse) based on the parameter S and Q.

Table 3. Vertex Availability

Status (S)	**Quota (Q)**	**Vertex Availability**
R	F	0
R	NF	0
Y	F	0
Y	NF	0
G	F	0
G	NF	1

Description of Table 3:

- Vertex availability 0 means the vertex is unavailable (the warehouse cannot be used to store the document)
- Vertex availability 1 means the vertex is available (the warehouse can be used to store the document)

The implementation of that condition in graph will be a model shown in Figure 3.

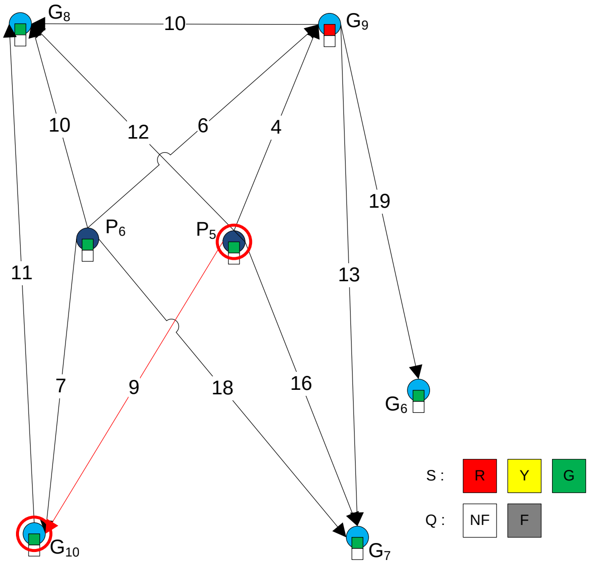


Figure 3. Graph Model with Parameter in Vertex G

C. The Use of Dijkstra's Algorithm

Dijkstra's algorithm is a greedy algorithm used to solve the shortest path problemof a weighted graph where the edge weights are non-negative.

Dijkstra's algorithm will be used to search the most appropriate warehouse in graph model. Dijkstra's algorithm to search the most possible path is as follows

Input : connected weighted graph, all positive weight, vertex a (vertex source).
Output : vertex z (vertex destination), L(z) (length of the shortest path from a to z).

1. [Initialization] Set $L(a) = 0$. For all vertex $x \neq a$, set $L(x) = \infty$. $T = \{x_1 \dots x_n\} = \{a \dots z\}$.
2. [Done ?] If there is $x \in T$ where $L(x) \neq \infty$ dan $x \in G$, find $L(x)$ which have minimum value. Stop. x is vertex destination with length of shortest path is L(x).
3. [Get next vertex] Choose $v \in T$ with minimum value of $L(v)$. Set $T = T - \{v\}$. Give permanent label to vertex v.
4. [Revise labels] For each $x \in T$ which adjacent with v, set $L(x) = \min\{L(x), L(v) + w(v,x)\}$.

Go to line 2.

Description:

x : vertex which have temporary label.
v : vertex which have permanent label.
L(x) : length of path from vertex source to vertex x.
T : a set of all verticesin the graph which have temporary label.
G : a set of all vertices of G (warehouse).

8. Mobile Reverse Logistic Application

A. System Architecture

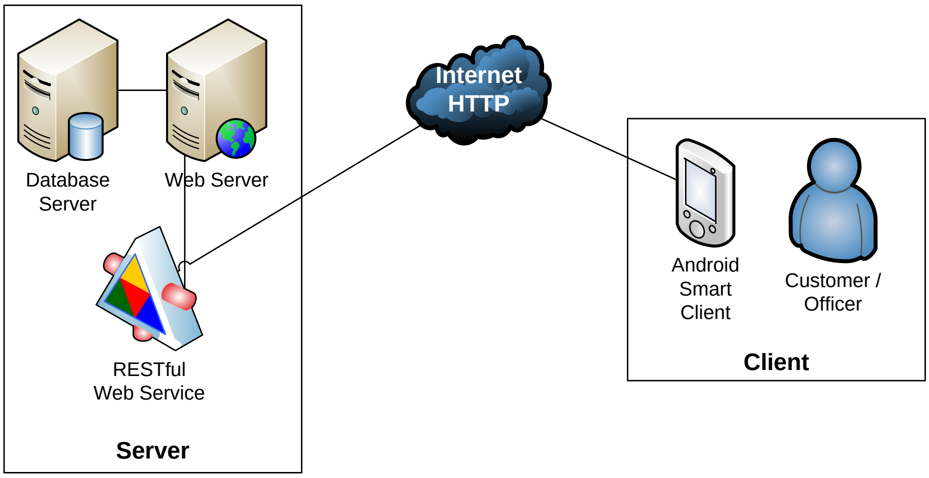


Figure 4. System Architecture

Description of Figure 4:

- Server (webserver) is a computing center, where there is business logic to manage the process of reverse logistics management. On the server there is a data base server that is used to store data on the entire reverse logistics process. Webserver serves to run web service.
- Webservice provides a service that will be used for data communication between client and server. Webservice read requests from the client and provide a response from the server. Webservice is using REST architecture and JSON message format because REST is simpler and lighter than SOAP or RPC.
- The user uses smart client applications that have been installed on their mobile phone (Android) to connect to the server and perform transactions. In order to be connect to the server, Android mobile phone must be connected to the internet.
- Data exchangewill be doneviathe HTTPprotocol.

Below is the reverse logistic sapplication software architecture.

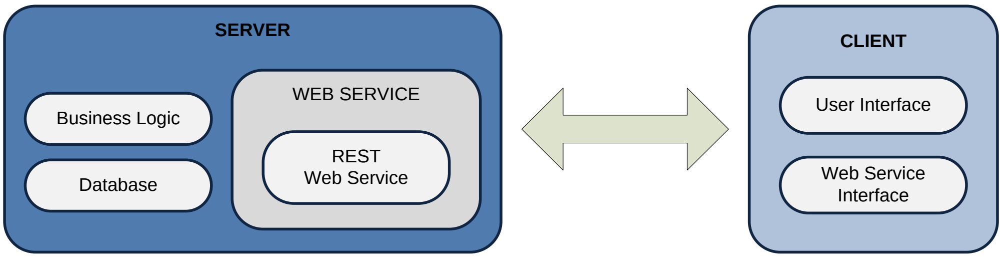


Figure 5. Software Architecture

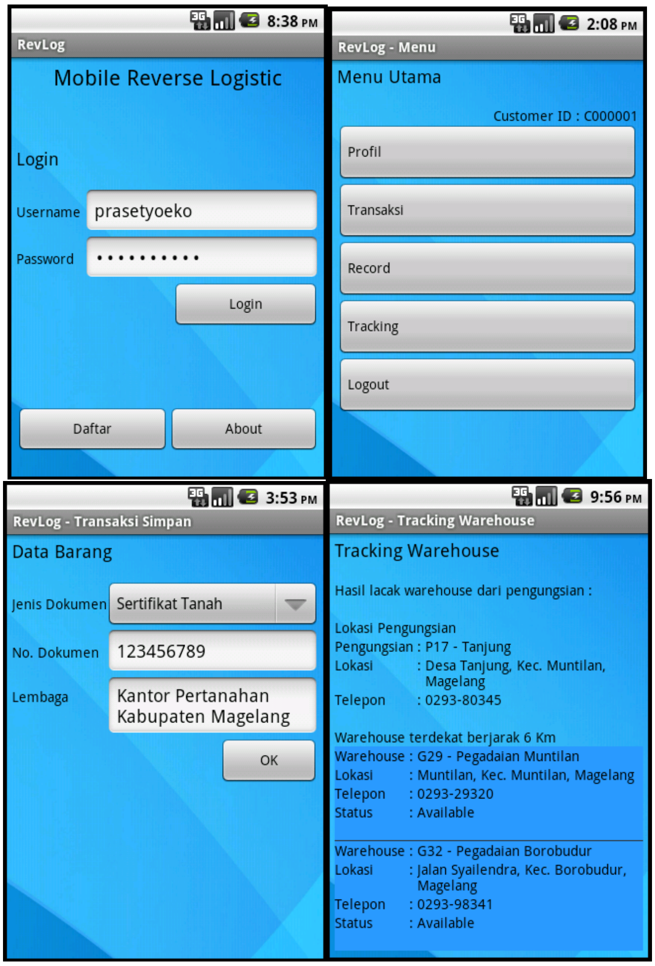
On the server side, there is a main database that contains data used by the system. Business logic is a controller that manages the activity of taking and using of data needed to provide a response to the request made by the client. REST web service read requests from the client then sent appropriate response. REST webservice using the data obtained from the controller that retrieves data from the database server. On the client side, the web service interface will capture the response given by theserverthrough aweb service. Messages which have been gained will be parsed and maintained by the business logic to be displayed to the user via the user interface.

B. Mobile Application

Reverse logistics is a smart client applications that can access data from the database server by sending a request which will be handled by the webservice to be replied with response from the server.

Webservice use REST architecture. REST webservice use method in HTTP such as GET, POST, and PUT. Message format used for webservice is JSON format with the advantage that is the size is smaller than the XML format. REST web service receives client request in form of GET, POST, or PUT methods with JSON message which contain values which is required by web service. On the reverse logistics system, there are 16 services used to handle the client request and the response from the server.

There are two kinds of Smart client application which are built, they are RevLog (application for the customer) and RevLogOfficer (application for the officer).



Username prasetyoeko
Password ••••••••••

Customer ID : C000001

Jenis Dokumen Sertifikat Tanah
No. Dokumen 123456789
Lembaga Kantor Pertanahan Kabupaten Magelang

Hasil lacak warehouse dari pengungsian :

Lokasi Pengungsian
Pengungsian : P17 - Tanjung
Lokasi : Desa Tanjung, Kec. Muntilan, Magelang
Telepon : 0293-80345

Warehouse terdekat berjarak 6 Km
Warehouse : G29 - Pegadaian Muntilan
Lokasi : Muntilan, Kec. Muntilan, Magelang
Telepon : 0293-29320
Status : Available

Warehouse : G32 - Pegadaian Borobudur
Lokasi : Jalan Syailendra, Kec. Borobudur, Magelang
Telepon : 0293-98341
Status : Available

Figure 6. Application Screenshot

9. Conclusion

In this research has been successfully built a mobile reverse logistic application that consists of server side and client side. On the server side, there are MySQL database and REST webservices with JSON message format, while on the client side there is an Android-based smart client application. Logistics network is modeled in a graph and the Dijkstra's algorithm is used to find the most possible warehouse locations.This application is expected to be able to reduce the loss which is resulted from the vanishing of important document of Mount Merapi eruption victims.

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