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Humanitarian Logistics Information System for Natural Disaster Case Study on East Java Under Coordination of Indonesian Red Cross

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***Abstract*— Indonesia is known as a country with high disaster risk. Many disasters occur such as earthquake, tsunami, landslide, and flood. Therefore an efficient and effective disaster management become one priority of government programs. One element of disaster management is humanitarian logistic, which is important to handle logistic, therefore disaster victim can receive any goods on time and enough quantity. In many events, some area has too many logistic, however at the other area shortage of goods availability. Information is an important factor to handle efficient logistic, therefore in this paper, we develop a humanitarian information system. The information system is developed using integrated web-based model under the coordination of Red Cross Indonesia (IRC), East Java province. In this paper, integration system involves many parties such as supermarkets, donors, volunteers, and disaster posts. The result of this research is logistic information system design consists of modeling process in the form of Data Flow Diagram, Entity Relationship and Web-based User Interface for the administrator, donors, shelters, supermarket and User Interface mobile device for volunteers.**

Keywords — Disaster; Humanitarian Logistics Information Systems; Supermarket; Indonesian Red Cross

I. INTRODUCTION

Indonesia is one of high-risk disaster countries since geographically the location is between four tectonic plates and has many islands scattered in a wide area. Not only has that situation, Indonesia had some volcanic belt lined lengthwise from Sumatera Island in the west to Nusatenggara in the east. Due to the facts above, humanitarian logistic is one of government priority [1].

Indonesia government take some efforts to anticipate disaster events by developing an agency for disaster management which is called as Badan Nasional Penganggulangan Bencana (BNPB). BNPB has the authority to coordinate disaster management among many agencies in Indonesia. Due to optimize the result, BNPB has much collaboration with some agencies in Indonesia such as Indonesia Red Cross (IRC).

One important part of disaster management is how to handle logistic effectively, therefore many researchers give attention in humanitarian logistics recently. According to Thomas and Kopczak [2], humanitarian logistic can be defined as planning, operating and controlling of distribution and stock of disaster relief efficiently and effectively. The process includes reliable information from the location where the disaster happened to the location of the distribution center with a purpose to reduce disaster victims suffering conditions. One of the main problems are unreliable information about the need for the victims, therefore some items are excessive available and the other items are shortages.

Research on humanitarian logistic is developed intensively to improve the effectiveness of humanitarian logistic. Ozdamar and Ertem [3] made a deep literature survey on humanitarian logistic. They divided humanitarian logistics into three important parts which are humanitarian logistic models, a method to get solutions and information system. Application systems that have been developed such as disaster warning systems that are developed by Global Disaster Alert and Coordination system which is under the supervision of United Nations GDACS [4]. Chang et al. [5] applied geographical information system to predict locations that are needed for help and some heavy equipment needed when the flood happened.. Saadatseresht [6] developed geographical information systems (GIS) for victim's evacuation in some disasters in Iran. Mete dan Zabinsky [7] developed a decision support system to find the appropriate location of medical aids and inventory levels that are needed for every medical stuff. Humanitarian Open Street Map [8] is developing an open source software that can prepare scenarios of the effect of a disaster for a better planning and operation aids that are called as Ina SAFE (Indonesia Scenario Assessment for Emergencies). Chen et.al. [9] developed GIS to facilitate information acquisition and decision making of equipment distribution when a disaster happened. In the first time, they developed mobile device application to know the need of the aid. In the second part, the developed database for warehouses location that can provide properly aids and in the last part, the developed mapping of the need and sources that are available and the best route to provide equipment fast.

Oktarina [10] has mapped management information system in logistic which consists of procurement, delivery, and inventory, however, they have not applied the information system software. Prasetyo [11] developed geographical information systems (GIS) for disaster relief for disaster by the eruption of Merapi Mountain. Mentzer et.al. [12] found in their research that logistic disaster relief assistance needs collaboration

network between many parties such as donor, disaster victims, and suppliers. Howden [13] concluded that humanitarian logistic information system can improve supply chain effectiveness by delivering on time and accurate information about any kinds of stuff that are needed and delivered, so the donors can know the need of the victims fast. Other than that, the good information system can improve collaboration network between any organizations involved. Sangiamkul, E. and Hillegersberg, J. [14] investigated the role of Information Technology in humanitarian logistic. They stated that proper information technology can improve efficiency and effectiveness of solving complex problems of disaster relief in term of reliability, responsiveness and agility especially the use of web technology, mobile, RFID and wireless sensor. Baldini et.al. [15] have done a research that is focused on a secure RFID Technology in the domain of humanitarian logistics since security is one of an important aspect of disaster relief. This research was done since logistic aids are prone to stealing and other criminal acts. They developed RFID system architecture, however in some events here are degradation of infrastructure and a future research on handling infrastructure degradation need to be observed. Most of the research above is how to develop an information system to help to determine disaster location, victim's need and provision of needs from the closest location. The research also tried to you technology optimally such as RFID where a warehouse has to prepare enough goods. In Indonesia, the problem is not the same. The problem is not about to find the closest route but more to provide the goods that are needed on time without shortage. The other problem is a weak collaboration between any parties in humanitarian logistics especially coordination between donor and government agencies, therefore a good logistic information system needs to be developed to handle the problem. This research tries to fill the gap by developing an accurate logistic information and involve donor from society and support from private sectors.

In this research, an integrated logistic information system is developed by involving government agencies, donor, and potential donors, ant the third parties who manage logistic distribution to the disaster area as fast as possible. The logistic information system is web base application for the government as the administrator. The government agency act as a disaster relief administrator. In this system, a government agency can input data of logistic needs and monitors any situation on time in any disaster locations. The second is an application for private sectors or individual who want to be a donor. With the system, the donors know the need in disaster locations fast and accurate. Later the application will be developed using an application that works in smartphone under Android and iOS operating systems for donor's convenience. The next application is for logistic distribution such as minimarkets of hypermarkets. The application can monitor the flow of the goods from the stores to the disaster locations. The monitoring system will be done by government agencies. The system is an integrated system, therefore information regularly so every party knows same information and logistic distribution can be done fast and fill the demand in every disaster location. The other problem can be handled by the system is manipulation for logistic distribution since the system in run transparently. The system is equipped with a verification system verification system that will be done by the volunteers in the field so the government agency knows that the aids are received by disaster victims as correctly. The volunteer will be equipped with smartphone application for the verification process. The developed logistic information system will be verified and validates using humanitarian logistic case in East Java province, Indonesia.

II. Supply Chain Management in Humanitarian Logistics

In humanitarian logistic, the supply chain is a term to describe distribution process to get goods to support disaster victims from the resources to disaster location as fast as possible. The goods resources can get from supplier or donors. In some organizations, they using logistic and supply chain terms at the same time. In principle, there is no difference between supply chain for commercial and humanitarian [16]. However, Ergun et al. [17] mention some significant differences between both of them which are:

- Demand uncertainty. Two earthquakes with the same magnitude result in different demand if one earthquake attack high-density population and the other happened in low-density population area. Or one happened in an area in developed country and under-developed country. The needs are difficult to predict the volumes or the types. This is affected by dynamic factors and difficult to be measured such as disaster characteristics, the local economy, and social politic conditions.
- Time uncertainty. In general, it is difficult to predict when a disaster happens such as for earthquake. Therefore need to stand by for the whole year and this needs more effort.
- Location uncertainty. Fault line can be known but it is difficult to predict when and where an earthquake happens. For the other disaster such as Typhoon, there is more information available based on historical data to predict the path of the typhoon, however often the typhoon can change the path. The location uncertainty results in the challenge in inventory and infrastructure position.
- Logistic unavailability. Resource of the aid is uncertain. The logistic availability is limited and more goods come from a donor where the goods given by donors is not fit with the victim's demand. It is difficult to develop a relationship with a local vendor in a short time, but it can be good opportunity to involve local vendor. Therefore in this research, local vendor is involved to participate in disaster relief.
- Collaboration between any parties in humanitarian logistic. Many resources can be used by many parties and difficult to collaborate to use some infrastructure and resources together without any disputes. Some parties can compete to achieve their own goals and does not focus on the victims. The parties involved in disaster relief also comes from a different background such as public and private sectors.

III. Analysis and Proposed System

A. System Analysis

One of Indonesia agency involve in disaster distribution logistic is Indonesia Red Cross (IRC). Coordination of IRC in East Java province is centered in Surabaya. When a disaster happens, some volunteers are sent to disaster location by bringing some goods needed in limited volume. Some districts have a branch of IRC to support center of IRC in Surabaya. There are some shelters available near some potential disaster locations to coordinate the volunteers and a center to store some goods for IRC in the province or in the district.

The shelter also has a function as a center of donors to send their aid to the victims. The donors can come from any organization such as foundations, companies or individuals. IRC prefer to receive aids in the form of goods than cash since up to now they do not have good administration process to handle the cash properly so it is prone to misuse the cash. To handle this problem, a donor can send vouchers to form some supermarkets and this vouchers can be used to shop in the closest supermarket to the disaster location. The disaster aids can be also in the form of public facilities construction such as facility of clean water facility and toilet.

Currently, the aids from donors are registered manually, therefore there is a historical note of the donor's aids. The other problem is no information about the needs of disaster victims that can be known by the donors. Donors usually send aids according to their opinions what are needed by the victims such as rice and instant noodle. As the result in many cases, rice and instant noodle become overstock and shortage for some needed goods. IRC also has difficulty to provide accurate information about a number of goods stock in their warehouse. Communication between IRC center, donors, and volunteers in disaster location use a smartphone and the applications such as SMS, BBM, and WhatsUp. The communication tools are efficient however many information is not accurate especially information about a number of stock and need of the victims.

B. Proposed System

Based on the problem analysis, this research proposes an integrated system that can overcome the communication problem between IRC, donors, and volunteers. In this research, we also propose involvement of goods and logistic providers to simplify and accelerate distribution system to the disaster location. The system is developed using web-based that can be accessed using a computer and mobile technologies. A mobile application is developed so volunteers can access the data easily and accurately. The system framework is shown in Figure 1.

Location of database processing center is in the S1 Logistic server, where all data and information boils down to the server. The server can be owned by IRC or it can host in hosting service providers. The operator can input information of logistic needs for every disaster location or monitors availability logistic is every location using web based application. The public can monitor IRC logistic distribution activities and needs, therefore, potential donors can register as a donor. Donors can see the logistic needs for every disaster event through the web and the application and can give a donation via money transfer to IRC account. IRC will accumulate all donations and allocate the donations to every disaster location according to the need of every location.

Logistic aids distribute to disaster location by setting an order to the supermarket or mini market that have online collaboration in the system. When supermarket gets an order through the system, the can use their distribution network to send the aid through the closest store or warehouse, therefore, the goods can be received quickly. Some shelter officers in disaster locations receive the goods and they will give confirmation through the system when the goods have been received correctly. This confirmation can be known by the donors and IRC administration center. This system guarantees the donations are used properly and the need of the victims can be updated on time and fast.

Volunteers in the disaster location will distribute the logistics taken from the post to the victims of natural disasters. If stock in a shelter is not enough and require additional stock, the shelter officer will enter data of goods required to the system. The provincial IRC or district IRC will monitor stock needs from the shelter, whether to send the stock from IRC warehouse, either from IRC province or IRC district or will order to the supermarket. The order will be made to the nearest supermarket to the natural disaster site so that logistics can be received as quickly as possible in the shelter and can be immediately distributed to the victims of natural disasters.

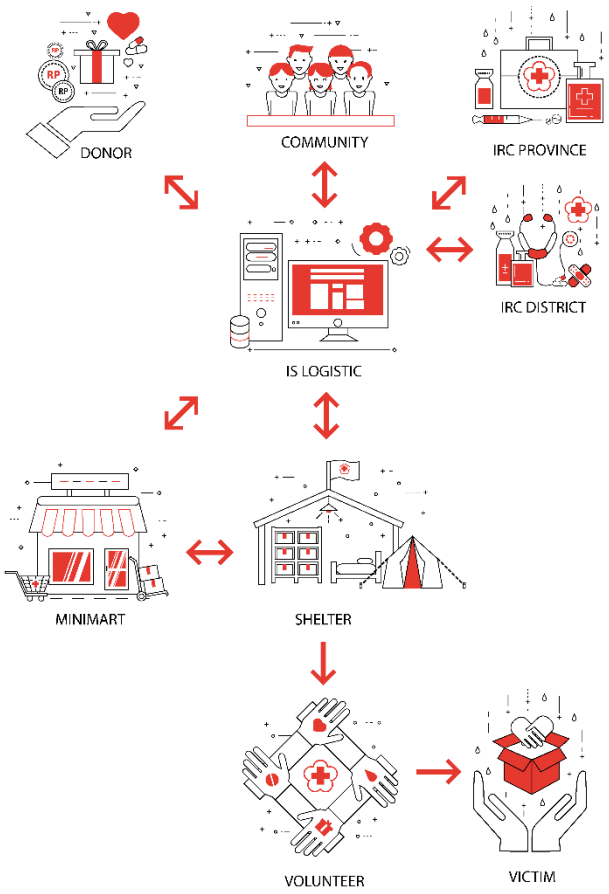

Figure 1: Humanitarian Integrated Logistics Information Systems

IV. Process Modeling

For process modeling is used the Data Flow Diagram. On figure 2 can be seen the Data Flow Diagram Level 0 consist of 6 processes, those are Master Data Management, Donations Reception, Orders Making, Items Distribution and Payment, Demands Request, and Reporting.

The Donations Reception process on process 2 consists of Upload Transfer Receipts and Verifications from IRC processes. First, the donor uploads his or her transfer receipt to the system. The IRC will give verification to the donor and save the donation data to the database. The Orders Making and Items Reception process on process 2 consists of Order Making by IRC, Items Received, and Payments processes. First, IRC makes orders to a supermarket. After the supermarket approves the orders, items will be sent to the desired locations or shelters. After the items are delivered to the destinated shelters, then the shelter officers send a verification to a supermarket and update the stocks of the items. The supermarket will get the verification and send invoices to the IRC to get the payment.

The Items Distribution process on process 4, consists of Volunteers See Shelters' Items Data and Volunteers Distribute Items processes. The volunteers view the items available to be distributed from the system and then they can choose which items to be distributed. After they received the items, the items data and the distributor data will be saved to the database. Demand request process on process 5 received information from shelters about the logistic needs of the victims of natural disasters in that area and shelter officers will enter the required data through their mobiles. Based on demands information entered by the shelter, IRC province will create an order to the supermarket.

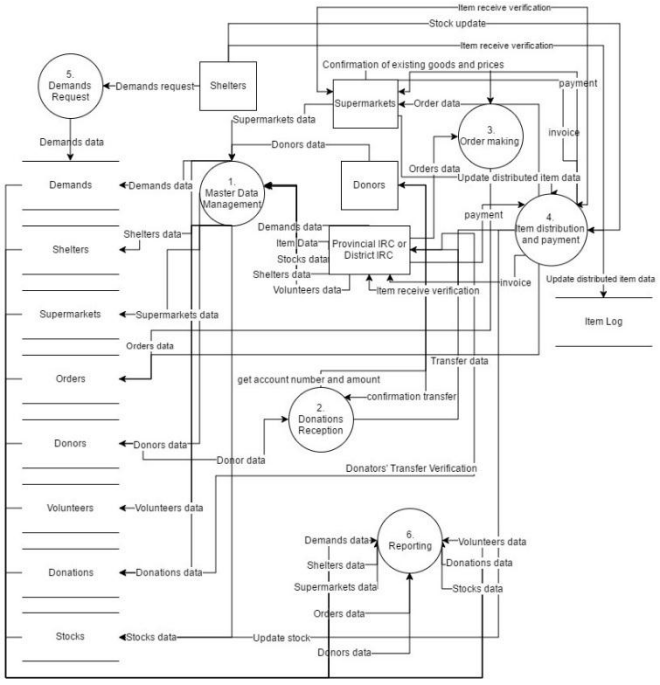

Figure 2: Data Flow Diagram Level 0

V. Results and Discussion

Based on the analysis and design of the process and data modeling conducted, the next step of this research was developing the menu. The user interface was implemented in the form of a dashboard for shelter, IRC, donors, supermarket, and volunteers.

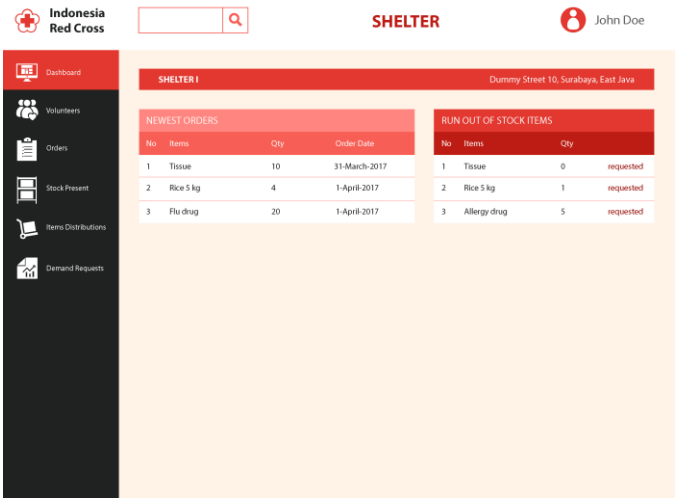

Figure 3: Shelter Dashboard

Every shelter has a dashboard where they can view the identity of the shelter, the 3 latest orders that are destinated to the shelter, and 3 out of stock items, as seen in Figure 3. Other than the dashboard, the shelter also has volunteers, orders, current stocks, items distribution, and demands requests menu.The Indonesian Red Cross (IRC) acts as the administrator on the system. The IRC's dashboard, as seen in Figure 4, shows the total of donations and orders in the ongoing month, the number of unfulfilled demands, the number of unpaid supermarket's invoices, and unverified donations. Other menus available are items, orders, donors, donations, shelters, volunteers, distribution, and shelters. The detail of these menus can be seen in Indonesian Red Cross dashboard.

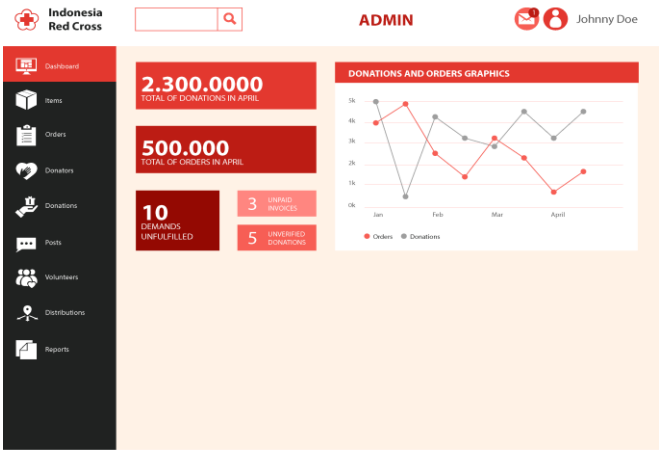

Figure 4: Admin of IRC

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In the Orders Menu, IRC can view and filter the orders made. They can also view the status of each order. The "details" text will pop up a box consisting of items bought by IRC when clicked. IRC can also make a new order by clicking the "Create New Order" as seen in Figure 5.

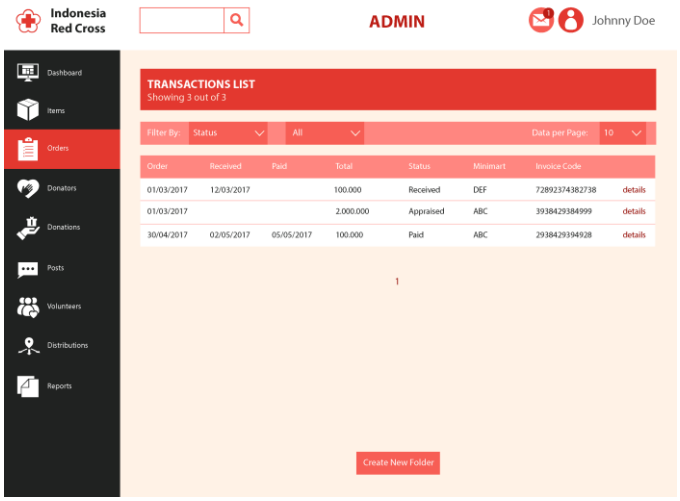

Figure 5: Orders

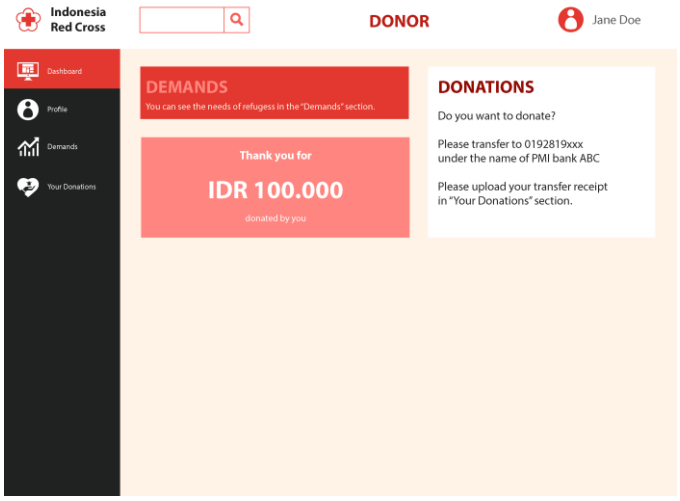

Figure 6: Donors

The donor's dashboard, as seen in Figure 6, consists of information about the menus available and the total donations donated by the donors. There is also a profile menu where a donor can manage his/her profiles; a demand menu where a donor can view the demands of the refugees, and your donations menu where the donor can view the list of his/her donations.

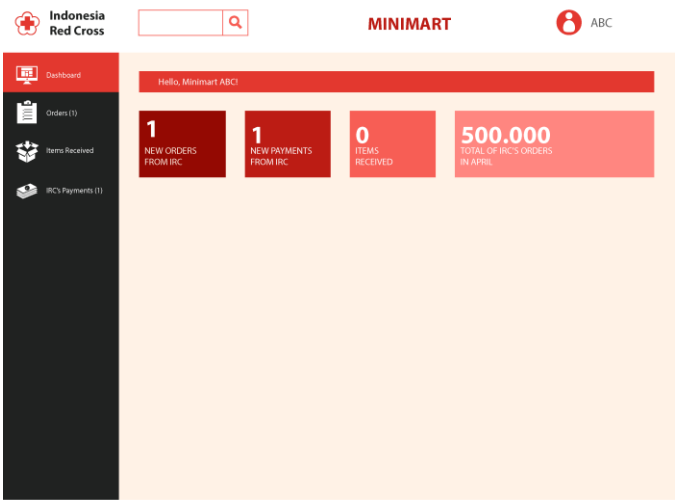

Figure 7: Supermarket

Supermarket, as the IRC's partners, is also a part of the systems. As seen in Figure 7, the Supermarket can view new orders from IRC, items received by the destinated shelter, new payments from IRC, and the total of IRC's orders in the ongoing month. The supermarket also have orders, items received, and IRC's payments menus. Volunteer's dashboard on the smartphone, as seen in Figure 8, shows his/her placement order, the number of unseen coming items of his/her placement order, and a number of times he/she has distributed items. The unseen coming items can be seen in the shelter's items menu. Volunteers can also manage their profiles in profile menu.

The menus available for each involved party can be viewed in Figure 9. These menus are available in the system, including the nested menus.

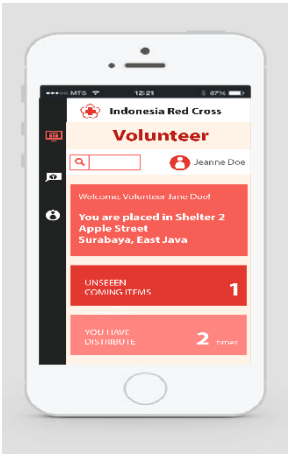

Figure 8: Volunteers Smartphone

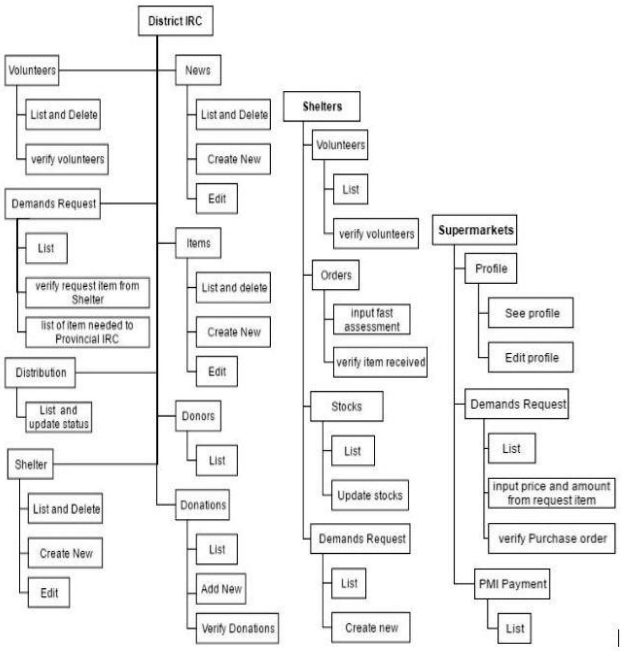

Figure 9: Tree Menu

VI. CONCLUSION

This research focuses on the integrated of Humanitarian Logistics Information System. The results of the research are the design of process modeling in the form of Data Flow Diagram and User Interface to display the IRC Administrator Dashboard, shelters, volunteers. This study has been completed with the design of menus, which includes the menu of Admin, shelters, supermarket. All designs are ready to be deployed.

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REFERENCES

[1] International Strategy for Disaster Reduction - ISDR, Living With Risk, A Global Review of Disaster Reduction Initiatives. United Nations, 2004
[2] Thomas, A. & Kopczak, L., From Logistics to Supply Chain Management: The path forward in the humanitarian sector, white paper, Fritz Institute, San Francisco, CA., 2005.
[3] Ozdamar, L. and Ertem,M.A., Models, Solutions and Enabling Technologies in Humanitarian Logistics. European Journal of Operational Research Vol.244. 1 July 2015.
[4] GDACS., Global Disaster Alert and Coordination System. Available online at:http://www.gdacs.org/ (accessed 22 April 2015)
[5] Chang, M. S., Tseng, Y. L., & Chen, J. W., A scenario planning approach for the flood emergency logistics preparation problem under uncertainty. TransportationResearch Part E: Logistics and Transportation Review, 43(6),737–754, 2007.
[6] Saadatseresht, M., Mansourian, A., & Taleai, M., Evacuation planning using multi-objective evolutionary optimization approach. European Journal of OperationalResearch, 198(1), 305–314, 2009.
[7] Mete, H.O and Zabinsky, ZB., Stochastic Optimization Of Medical Supply Location And Distribution In Disaster Management. International Journal of Production Economics, 2010
[8] Humanitarian OpenStreenMap, Available online at: http://hot. openstreetmap.org/projects/indonesia-0 (accessed 22 April 2015).
[9] Chen, A. Y., Peña-Mora, F., & Ouyang, Y., A collaborative GIS framework to support equipment distribution for civil engineering disaster response operations.Automation in Construction, 20(5), 637–648, 2011.
[10] Octarina, R., *Pemetaan Sistem Informasi Manajemen Logistik Dalam Penanggulangan Bencana di Indonesia*. Seminar Nasional Aplikasi Teknologi Informasi 2008. Yogyakarta, 2008.
[11] Prasetyo, D.Y. and Utami,E., Perancangan Sistem Informasi Manajemen LogistikDalam Penanggulangan Bencana Alam Gunung Merapi Berbasis Gis (Geographic InformationSystem) Di Yogyakarta. Seminar Nasional Informatika 2011. Yogyakarta, 2011.
[12] Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N. W. Smith, C.D. and Zacharia, Z.G., Defining Supply Chain Management, Journal of Business Logistics, 2001.
[13] Howden, M., How Humanitarian Logistics Information SystemsCan Improve Humanitarian Supply Chains: A View from the Field. Proceedings of the 6th International ISCRAM Conference – Gothenburg, Sweden, 2009.
[14] Sangiamkul, E. and Hillegersberg, J., Research Directions in Information Systems for Humanitarian Logistics. Proceedings of the 8th International ISCRAM Conference – Lisbon, Portugal, 2011
[15] Baldini, G., Oliveri,F.,Seuschek,H.,Hess E., Braun M., Secure RFID for Humanitarian Logistics.www.intechopen.com, Siemens Ag.Italy, Germany, 2011.
[16] Balcik, B and Beamon, M. Facility location in humanitarian relief. International Journal of Logistics: Research and Applications, Vol. 11, No. 2, April 2008, pp. 101–121.
[17] Ozlem Ergun, Pinar Keskinocak, Julie Swann and Monica Villarreal," Uncertainty, damaged infrastructure, politics highlight top-10 challenges facing analysts during a disaster", http://analytics-magazine.org/supply-chain-management-humanitarian-logistics, 2009 (Accessed 25 June 2017)