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INTEGRATED DISASTER MANAGEMENT SYSTEMS (IDMS): A PROPOSAL DECISION-MAKING SUPPLY CHAIN MODEL USING MOBILE INFORMATION TECHNOLOGY

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Abstract. Disaster management is a very important management approach to conduct both before and after the disaster. In order to effective disaster management, all of these processes that include modern technics should tackle as a whole. Not only mobile technologies can use in disaster logistics systems but also it can help the decision making to disaster operations managers. In this study, a kernel algorithm has been developed for decision-making software and the aim of this software proposes to bring a new approach to integrated disaster management as well. At the same time, it is aimed that logistics activities in integrated disaster management will be carried out together with other disaster response and relief activities to be more efficient and productive. Moreover, the experiments conducted with the proposed mobile software algorithm model and decision support system in the research, the use of logistics services which use Floyd-Warshall Algorithm was performed on mobile devices. In conclusion of the research, it is showed that an algorithm and mobile software can be incorporated into a decision support system and its results can be delivered to those in the field crew. In addition to these results, it has been revealed how beneficial the use of mobile software in disasters can be, and future work will be the beginning.

Keywords: Disaster Management, Mobile Technology, Integrated Disaster Management, Disaster Information System, Supply Chain Management.

AMS Subject Classification: 68W27.

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1 Introduction

Computer and information technologies make easier daily life day by day with state of the art technology. This technology has become easier to use when it is the smallest and to go into our pockets. The decision Support system is the best assistant disaster manager to conduct this process. Information consists of knowledge and communication technics working together with certain rules. Last decade, mobile technology is more rapid developing especially. One of the critical processes of disaster management is a disaster logistics problem. It is imperative that disaster survivor needs are met and that disaster survivors have a robust logistics service for a successful rescue and disaster relief mission. Mobile technologies can use for logistics services that are crucial in disaster. Numerous software applications have begun to be developed on mobile devices, and together with this, a large number of software application areas have emerged. By managing these processes well, it is possible to eliminate life losses in disasters and reduce economic losses. Although modern disaster management is known in the literature as a combination of risk and operation management, it does not includes all of the information technology processes. Although there are many definitions of disaster, in general, disaster is a catastrophic event that is interrupted human daily life suddenly. Disasters can be divided into two groups according to occurring sources, one of them is origin from natural sources, the other is a manmade disaster which includes technological matter. In literature, the known disaster management is divided into five subgroups in which they include biological, geophysical, hydrological and meteorological sources. These five group has more than thirty sub-types according to the classification approach. (Guha-Sapir et al., 2012). The technological or manmade originating disaster has a severe effect, however, people are affected by natural disaster much more. Considering with a survey on affected people in 2017, it has seemed 318 natural disasters have a great impact on human life among 122 countries over the World. A survey reported that 9503 deaths, 96 million people were affected, and then approximately $314 billion USD total economic losses in resulting (Wallemacq, 2018). It seems that disasters influence human daily life strongly. If a country is in a big territorial area where includes high disaster risk, the influence of the disaster is higher than the other countries (Lixin et al., 2011). Information and Communication Technology (ICT) made human life easier last few decades. Knowledge can be obtained by devices such as GSM phone, tablets, computer, glasses and electronic billboards nowadays. To getting the information methods are changed in the last two decades. When a disaster occurs in the World such as a severe earthquake, flood, landslide or technological, we can take information in seconds by communication technologies especially mobile. As developing mobile and internet technologies, many decision-making processes become easier, robust and rapid. These technologies are useful in the social, economic, public and private area, also beneficial. For Instance, These technologies are performing such as whether school kid arrives at school, send a marketing paper by a pop-up message, pay tax services, news about disaster occurrence. ICT and their components implement in disaster recovery and response nowadays. Disaster management defines as "An applied science which seeks, by the systematic observation and analysis of disasters, to improve measures relating to prevention, mitigation, preparedness, emergency response and recovery" (Carter, 2008). The disaster management system is a planning period of the disaster which includes four phases as you can see (Altay & Green, 2006);

a) prevention,

b) mitigation,

c) response,

d) relief.

In our experimental design, Integrated Disaster Management System (IDMS) can be divided into two main parts. The former, two (a,b) phases are before disaster occurrence which includes risk assessment and preparedness, the latter, (c,d) phases are after disaster occurring which includes response and recovery action. Moreover, the first part of these periods generally includes a long-term policy that is strategical plans, decision-makers focus on the long-horizon project plan. The second part of these period includes short-term operational and tactical plans. Communication is very crucial when a disaster occurs. Disaster information is transport by communication infrastructures such as satellite, internet or GSM networks between disaster areas and Emergency Operation Management (EOM) center. Integrated Disaster Management Systems (IDMS) can accomplish these requirements in considering with this necessities. The aim of this study proposes a model in disaster management as an integrated management approach. According to the new proposed method of disaster management, communication and information systems are combined to IDMS, and to intend solving a natural occurs disaster problem. This study focuses on disaster management information systems and natural disasters, especially earthquake.

2 Literature Review

The wireless sensor network (WSN) technology has been applied in monitoring natural disasters last few decades. It is known that a natural disaster can be strictly traced by improved several kinds of sensors. (Chen et al., 2013). In Literature, the disaster management system can be classified into several types according to their types such as the subject type for instance game theory (Seaberg et al., 2017). Authors surveyed 57 papers between 2006 - 2016 using keywords combination “game theory” and “disaster”, some of them is an academic journal and little of them are proceedings books. The authors divided into two categories their survey, one of them is a disaster management phase and the other is the disaster phase. They found that many papers are in the second phase of the disaster management system, response and recovery phase, and is raised after 2011. Some research papers focus on geographic information systems (GIS) which include information about location, events and their types. With respect to information systems of natural disaster data management can be divided into three main components Communication, Data Distribution and Data Management Systems (Assilzadeha & Mansora, 2004). They mentioned their paper using these three methods to decrease the financial asset, a probabilistic period of disaster and rule-based management. The authors are only inspecting for disaster data longitude and latitude, magnitude and scale to process disaster severity. Telemedicine is the new approach for disaster management and wireless telecommunication technics (Chu & Ganz, 2007). It is given priority in this research paper decision-making processes in respect to managerial and information approach. Decision making proccess is another important approach part of the Disaster Management. A paper is surveyed by authors focus on a new approach to design, capturing and developing a decision models (Coles et al., 2016).

2.1 Disaster Information System

It was not expected that social media has become more popular. By the time social media which is online has impacted on human life greatly. Present day regarding disaster literature, the authors indicated that online social media is a great information resource in disaster management (Ghosh et al., 2018; Hong et al., 2018). Disaster data and information sharing are most valuable assets as much as other types of data and information such as bank account, private and public identification, bill of pay. The data and information shared in the disaster have been widely investigated by authors (Chiu et al., 2010). The researchers to address these problems, they have present a Disaster Notification and Resource Allocation System (DNRAS) based on an Alert Management System (AMS) applying Web services. Disaster information that stored in a special database system uses in a various research area. Past disaster information is indispensable for taking lessons from the past, examining their reasons, keeping in mind the calamity and for disaster planning related works. (Ergenc & Baris, 2018). The aim of researchers is to try to find out a hazard profile definition a city Istanbul where has historical disaster background. The authors state that defining of disaster category and criteria is run by Analytic Hierarchy Process methods and is promoted a risk profile for Istanbul. Numerous studies investigate web-based social networking information to comprehend the problems to build up pre-disaster and post-disaster mitigation planning. Last decade Social network is widely used in disaster operations management (DOM) and disaster information systems (DIS). The authors (Kim & Hastak, 2018) surveyed associations that are cooperations in Facebook pages during disaster response activity. In this survey, experiment with social parts and key players is utilized for interpersonal organization analysis. And also study is prescribed activities to enhance the viability of data dissemination through web-based social networking such as Facebook and Twitter (Bandyopadhyay et al., 2018). The other social media-based communication tools for disaster is proposed by (Palen & Hughes, 2018). According to this research, overviews focus on the quick ascent of internet-based life in a scope of failure encounters, looking into themes of subject revealing, network arranged figuring, dispersed critical thinking, and digital volunteerism as types of sociotechnical development. There are many surveys in respect to social media-based (Castillo, 2016; Hughes & Chauhan, 2015; Dufty, 2012; Latonero & Shklovski, 2011; Fitzpatrick & Mileti, 1994). An information system to reduce disaster impact was proposed by (Sterlacchini et al., 2018) that name is SIRENE (Sistema Informativo per la Preparazione e la Risposta alle Emergenze) which is based on Spatial Data Infrastructure (SDI). SIRENE adaptably setting and getting key data from the neighborhood as well as remote storehouses to adapt to different disaster stages. The implemented framework gathers, questions, and examines geographic data gave intentionally by spectators straightforwardly in the field (volunteered geographic data (VGI) reports) to distinguish conceivably crucial environmental conditions. Testbed implements of SIRENE have been communicated in 18 uneven or mountain districts, (12 situated in the Italian Focal Alps of northern Italy, and six in the Umbria area of focal Italy), which have been influenced by normal peril initiated catastrophes (landslides, debris flows, floods, and wildfire) for the last decade and experienced critical social and financial costs. The disaster logistics information system can help survivors after a disaster (Koesuma et al., 2017). The authors developed mobile software for Android ecosystems which name is dLOGIS (dLOGIS-Disaster Logistics Information System) to help people logistics management in disaster (Aydin et al., 2016). Purpose of this research paper that mentioned information technology is to recover national inhabitant who is using mobile technology in a natural disaster. Combined disaster and geographic information system model are proposed by (Miyazaki et al, 2017). In a proposed model by authors, survivors can share, spread or managed map and their information in regard to medical goods and logistics information over resilient information management (RIM). This system can work standalone Wi-Fi network which apart from the internet or other communication infrastructure. Thus if a network shutdown after occurs a disaster, this system can run on their own Wi-Fi devices. In Communication and Information Technologies (CIT), advancements progressively led the catch of encounters that outcome from disaster and mass crisis occurrences (Liu et al., 2012). Information in disaster should be defined and classified according to their needs. In respect to this needing, some of the pieces of information require a template to ease of use. The authors (Lee & Bui, 2000) propose a templated-based information system for disaster management. In this survey, Lee and Bui (2000) propose an information-based template which predicts to previous disaster relief activity for helping decision makers. While the template-based information system helps disaster manager, it diminishes misunderstanding and miscommunication. Data mining technics is used to define disaster risk including financial lost (Olson & Wu, 2017). Disaster Operations Managers decide on a strategic, tactical, and operational activity can support by decision support systems to enhance disaster preparedness, response, and recovery (Rauner et al., 2018). Another DSS framework in disaster management systems is proposed by (Cioca & Cioca, 2010) in a case study. Available disaster management frameworks give a graphical statement of catastrophe-related information, however, are restricted by the way that they do not give dynamic choice help capacities for instance to optimize resources allocation, scheduling, vehicle routing (Kondaveti & Ganz, 2009), (Rauner et al., 2018). A project is suggested by (Coles & Zhuang, 2011) provided and conducted decision makers on the best way to choose and create developing relationships to improve resource utilization and project outcomes in disaster occurrence.

2.2 Logistics Activity in Disaster

Disaster data and information uses in logistics activity, relief operations, and decision-making process. The strategic arrangement of assets to give help to catastrophe survivors and the fitting arranging of these planning exercises are basic to decrease the affliction induced. A paper that surveyed SCP in the disaster was proposed a framework about humanitarian and disaster relief supply chains (HDRSC) by the authors (Day et al., 2012). Numerous organization operates with each other in order to successfully struggle a disaster by sharing their resources, data, and information. Combination of these components about disaster consolidated in two main methods, one of them is operation research methods, the other is geographical information systems (GIS) to aid multi-organizational decision making (Rodriguez-Espindola et al., 2018). Logistics in disaster management includes stochastics decision making process. This process is generally modeled by operations research methods, for instance, two-stage stochastic programming (Tofighi et al., 2016), probabilistic vehicle routing (Ahmadi et al., 2015); multi-modal and multi-commodity distribution model (Moreno et al., 2016), probabilistic network model (Yücel et al., 2018) and (Alem et al., 2016), fuzzy stochastics network problem (Torabi et al., 2018), multiple planning period for disaster management (Hasani & Mokhtari, 2018), facility location problem (Boonmee et al., 2017), marine transhipment (Baskaya et al., 2017). Dynamic vehicle routing model is proposed by (Maghfiroh & Hanaoka, 2018) while response activity accomplishes in disaster. The conclusion of this study demonstrates that using various vehicle type is harder when they operate in relief activity. The authors prove that the variation in vehicle type has some advantages although the vehicle type is different from the others. The philanthropist caseload in catastrophe is developing quickly while financial aids are declining. The disaster Operation Managers (OM) should accomplish more with fewer resources. OM, on the other hand, prepare can unequivocally reinforce altruistic specialists gave it tackles pressing gracious issues and make a translation of its examination into easily implementable gadgets whose ampleness can be affirmed (Besiou et al., 2018). Humanitarian logistics and supply chain are surveyed by (Abidi et al., 2014) to classified performance measurement into five stages. The main focus of this paper is the managerial approach of disaster supply chain management. Supply chain management is a crucial public and private sector according to their paper. The conclusion of their paper displayed that measuring and management performance of the supply chain must be expanded on their strategy. And also, in light of the discoveries of the writing audit on execution estimation and administration in the business and helpful field, the first arrangement of 94 execution estimation markers in compassionate supply chains is displayed. Moreover, the paper demonstrates key issues why execution estimation and administration frameworks have not been broadly created and methodically actualized in compassionate supply chains and are not some portion of the inventory network technique. Disaster logistics surveys can be generally classified in OR/MS science. The authors Altay & Green (2006) are mentioned their paper disaster logistics publication characterized in the operations research paper. Medical commodities in a disaster are vital important according to Barbarosoglu & Arda (2004). They proposed a probabilistic mathematical model which was a two-stage multi-modal transportation network. In this survey, the authors developed a model from the depot to the disaster area medical goods carry on the network. Their developed the model covers three randomly states, one of them is capacity, the other is arc capacities on the network, and then the lastly randomness supply amounts. Besides, the model approved probabilistic information in respect to real disaster data includes expected mean.

2.3 Brief Evaluation of the Literature

This paper focuses on 65 papers that pertain to computers information system in operations research and disaster management. The papers starting from beginning of the millenium are mainly subjected disasater management to save the survivors. Alhtough, many problem are surveyed by researchers relating to disaster management in the first decade of the millenium, there are a lot of problem about disaster management and information systems still for solving to save the they. Contribution of the research in literature, it is showed that computer and information technology how can help the survivors to alive after occurring the disaster and also to manage logistics systems.

3 Method

Information and Communication Technology (ICT) is rapidly progressing, developing and implementing in a wide area such as social, economic and cultural. People want to communicate with each over the internet without no limitation when they connect to the networks as for LTE, 4G, ADSL, CDMA. They can connect to the internet over their GSM (Global System for Mobile) as a mobile and share all of the information that they want to. For instance, some patient might want to share their health data with a doctor over a mobile application (Santhi & Sadasivam, 2015). It is known that communication and information technologies include several components to conduct their operations. Collected data using these components in it can be stored in an electronic environment in which name is a database. According to the system approach after a data processing, it turns into measurable and valuable things which include an information (Mason, 1978). Data enter the system as a raw thing, and process it, convert into information after this progress as it is displayed in Fig. 1. For instance, academic survey, which is found out by the author, classification is a most important indication for this information process. (Levy & Ellis, 2006).

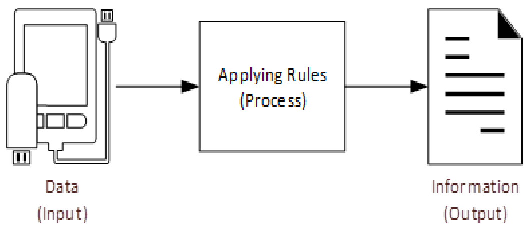


Figure 1: Convert from data to information

In IDMS approach, data as an input can be obtained from various sources such as images, maps, databases, sensors devices, satellite data from microscale to macroscale. Obtained data convert into information after processing with applying rules. IDMS and Information management in a disaster can be divided into three main group according to the system approach, supplying of the data, distribution of the information, and management of the information. In the first phase, data acquires from outer or inner environmental devices to store on the database to use later. The raw data getting from sources might be an information such as disaster location, latitude, longitude, altitude, temperature, earthquake severity. The second phase covers results which convert the raw data into knowledge. In this phase, information is classified according to their needed type on the data warehouse. The last phase is IDMS information management systems include information which is disaster types in accordance with GLIDE (GLobal IDEntifier number) codes. GLIDE code includes information which contains disaster type, year, number of disaster, national identification codes to define a disaster occurring and to store standard form for databases, for instance, the code FL-2018-000001-TUR defines the type of disaster flood, a year in 2018, the sequence of disaster 000001, country of place is Turkey. Disaster information systems should include in several types of data handling in informative (McLoughlin, 1985), and a template-based information system offered by (Lee & Bui, 2000). Disaster information in IDMS disseminates over internet and newsrooms which contains many informative data compactnesses (Tanner et al., 2009). In the East Japan Great Earthquake on March 11, 2011, vigorously harmed by the tremor, and the blockage in the cellular phone infrastructure was seriously substantial, had in excess of 19,000 survivors and collapsed an immense number of houses, and buildings, and also seaports. The quantities of the call demands grew up eight times bigger than the usual case, and the most extreme blockage time had been around 30 min soon after the earthquake (Shibata et al., 2003). Considering in this situation called crisis management, in first 30 minutes after an earthquake, phone call by from survivors blow up. This case can be explained as graphically Fig. 2.

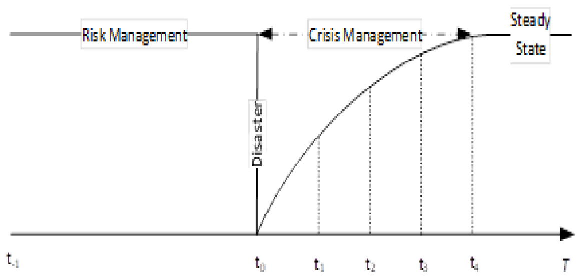


Figure 2: Time progress for the disaster, Macit, 2018

Although disaster type is different from the other, type of time progress is generally the same as each other. Time progress that depicts on Figure 2 can be inspected in two phases, the first time period is t_1 is before disaster which is calamity is not impact yet and the second time period is between from t_0 to t_4 is after the disaster which state is catastrophic. In the first phase, it is known as risk management (RM) period among t_1 and t_0 on the timeline. In this stage, people are not impacted by disaster yet, and live normally goes on.

Table 1: Disaster progression on timeline

Time Division	Status	Flow on Time
t_1	Just around the disaster	Before the disaster
t_0	Striking the disaster	On the time
t_1	Catastrophic statement	An hour after
t_2	Crisis management and operations	One day after
t_3	Disaster management	One week after
t_4	Steady state	A few months later

Managerial approach complexity starts from t_0 on the timelines when disaster strikes on suddenly. Because of occurring the disaster, Status between from t_0 to t_1 becomes catastrophic on the timeline in view of Table 1. Decision maker needs much more information regarding the disaster to struggle with a catastrophic event in this stage. Information needing in this period is significant and it spread heavy data transmission among survivors and emergency responders. Accurate, and giving on the time information is vitally important for successful disaster management activity and hindering the lost especially in catastrophic status. The latter time division, t_2, the intensity of information is still high volume because of crisis management and vast operation decisions. One week after disaster status, t_3, crisis, and operations management convert into disaster management system which information requirement is less than before status t_2. When the time T reaches to last status t_4 life is a normally steady state which information needing is stable. Considering all of these phases, information among these catastrophic stages are more compactness than the others and they are caused by heavy data transmission traffic on the network. (Shibata et al., 2003). To Solve this data workload problem on the network, disaster information should be classified in accordance with template-based information types (Lee & Bui, 2000). The information carrying data in a disaster is used by the manager to decide in the crisis. Managers demand several types of informative data that are logistics or humanitarian knowledge with respect to calamity. These types of data that cover recovering and relief periods in disaster management help to struggling with catastrophe. In respect to progressing disaster, information can be inspected by two main groups, one of them is news information and the other is operations activity information. For instance, While GLIDE codes represent news information about disasters, the operation activity information covers all of the disaster data. And then, the information of the disaster is demanded by diverse organizations to processes for disaster recovery and relief. The disaster can be categorized as GLIDE codes in respecting o their types, as mentioned earlier. These codes that include crucial information about disaster maintains in distributed databases in the world. A software developer who is implementing the disaster application can use these type of information in their software to aim follows the disaster. When an application that includes the GLIDE code is carried out disaster software application, the disaster could be followed by this software step by step, showing phases in the Figure 2.

3.1 Information Progress Response and Relief Periods

The disaster response period includes the more complicated situation in compare with disaster relief period in usual disaster management respect to information transmission. The information carrying in disaster aims to solve many vital problems. Information flow can be divided it into three stages such as supply management, operations management, and information flows in the disaster area. Information streams from the supply center to the disaster area connect with the operations center. At the same time, feedback information of goods flows through supply chain management system.

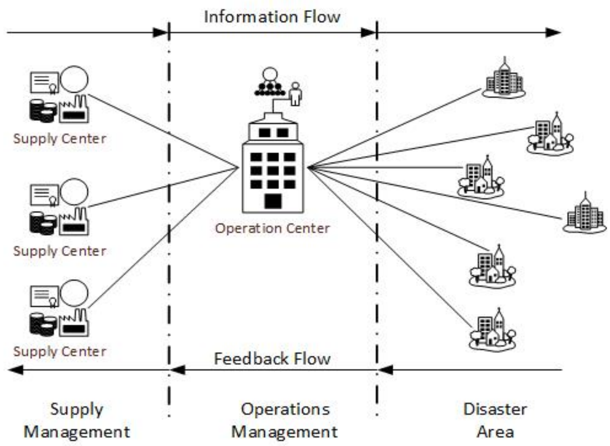


Figure 3: Information progress on disaster management system architecture

Operations activity information exemplify as a knowledge, impacting of catastrophic, disaster response, victim loss, assets lost, survivors, disaster severity and disaster recovery and relief information. All of these information has various densest with respect to transmissions of data as depicted in Figure 3 respectively.

Table 2: Progressing congestion of disaster information

Severity of Disaster	**Disaster Information**	**Flow on Time**	**Impact Information**	**Response Information**	**Victim Lost**	**Assets Lost**	**Survivors Information**	**Relief Information**
t_1	Low	null	null	null	null	null	null	null
t_0	high	high	low	low	low	low	high	low
t_1	very high	very high	very high	high	high	very high	very high	very high
t_2	very high	very high	very high	very high	very high	very high	very high	very high
t_3	high	low	medium	high	high	high	medium	high
t_4	low	low	low	null	medium	medium	low	low
SS	low	null	null	low	medium	low	null	medium

Not only disaster information gives informative news, but also it can use managerial operations such as the recovery and relief operations. The managerial operations have to use several types of data to specify the decision. These data should be integrated as a whole managerial stage and among all decision makers. Decision makers in the disaster operation center should have all flow information for making inferences, meanwhile. When a disaster occurs in a municipal area, the survivors call to officials to response them about disaster information. There are many kinds of disaster information which as mentioned earlier contain in Table 2 about this situation. Although the composition of these information varies in respect of catastrophe type, from time to time combining of information explain the disasters characteristics what big is. As mentioned earlier, natural disaster information progressing was proposed by (Assilzadeha & Mansora, 2004). They were designed natural disaster data and information management system to transmit from disaster area to operation control center. In this system, it only shows that information flows disaster area, do not contains feedback information for survivors. But integrated disaster management system (IDMS) supports to transmit whole information from disaster area to the operation center or vice versa, because of survivors needing information whether the relief team comes or not. Numerous in which was developed web or mobile applications help survivors transportation the data over GSM, internet or other networks. (Zhou et al., 2017; Li et al., 2017; Otomo et al., 2017; Hirohara et al., 2017; Goto et al., 2017; Tabata et al., 2016; Takahagi et al., 2015; Kikuchi & Shibata, 2015; Tomoyasu, 2014; Macit, 2010). Dynamic data and information speedily change at time division between t_1 , t_2, and t_3 on Table 2. Moreover, managers have to conduct all these phases by using information. Management information systems (MIS) approach could be using in this types of information. In an earthquake covering the time period from t_0 to t_3, proportions of information transmissions are exemplified 32.46% humanity services and disaster relief, proportions of health and medical care 8.36%, proportions of search and rescue 8.0%, and last proportions of public information 7.64% percent, top-down respectively. The remain proportions of information consist of other services such as assessment management, public relations, and services (Celik & Corbacioglu, 2010). It is seen that data and information management is the denser in the first three periods of time progress than the other time periods. Additionally, information management should be synchronized among all of the disaster responders organizations which they are goods suppliers, depot, disaster search and rescue teams. Disaster information and property supply cycle are depicted in Figure 4. In order to sustainable disaster response and recovery operation, suppliers can provide goods for by using information systems.

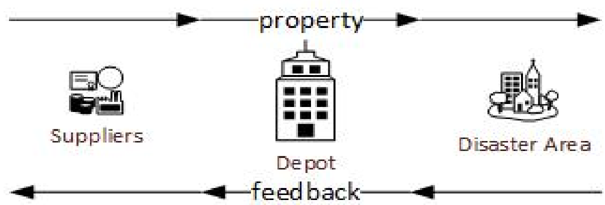


Figure 4: Commodity versus information flows on disaster network

When the required goods inventory level is low level, coming feedback information from disaster area support reclaim more property to send goods to disaster fields. Information flows between suppliers and client (survivors) are to be robust enough to carry goods. These type of information can transport with several methods as GSM, cable, satellite and wireless network. All of these methods should be carried at the time whole disaster information. Interagency in the disaster area, emergency information flows could be varied from agency to agency (Bharosa et al., 2010).

3.2 Proposing Integrated Disaster Management System $IDMS$

Disaster management is required key elements to success such as data, information, decision rules and time. With respect to disaster management, integration is combining and linking whole information, transportation, decision, management systems. The most of the time public or private disaster recovery and relief agencies are work together the first time when the disaster the occurs. Because of this case, these agencies have to agile struggle against any type of disaster using information flows. Disaster managers decide to act according to some dispatch rules regarding commodity or goods. Dispatching problems which are covered by supply chain management cause unsuccessful disaster response and recovery activity in disasters. Because of these problems goods and activity periods have to synchronized between suppliers and survivors. Synchronization is provided by information and communication systems that setup in disasters. Supply Chain Management (SCM) is the most popular approach in disaster management. Although there are many definitions of the SCP, it is not any consensus of the term that what does it mean. In general, the term SCP covers whole logistics activity in the firm in which the start of entering the factory for manufacturing goods and obtaining goods from the end of the production process. While low-level inventory is not satisfying the demand, high inventory level is a big budget problem. Because of this case, inventory level should be optimum level any

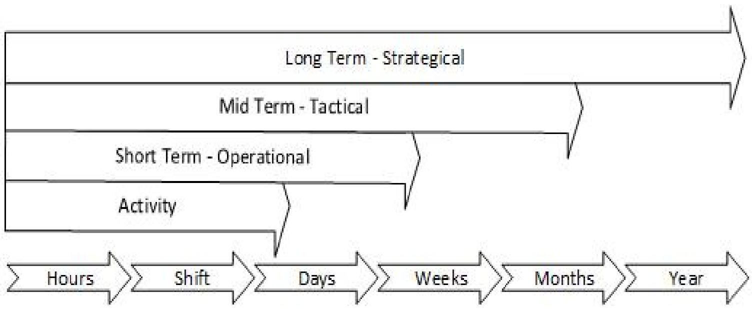


Figure 5: Basic SCP operation principles in time-window

disaster operational case. The best way of the optimum inventory level is using the SCP method in disaster. Not only the SCP method uses short-term operation level in disaster, but also it should use any management level in a disaster such as strategic long-term planning. Information flows in SCP is a major requirement aspect of IDMS. Especially information progress on disaster is more information needed to accomplish disaster management. According to time progress on the disaster, SCP is more effective in t_0 and t_4 phase because of activity concentration. IDMS is the key element of the SCP to accomplish successfully. The main idea of the IDMS is to evaluate from a disaster management system to integrated disaster management which is the best disaster management system. IDMS also uses any pieces of information on the disaster management system to decrease entire losses. When a team member request demand from the operation center using mobile devices, operation center manager (CentCom) controls the demand using SCP computer program in IDMS method. SCP computer program controls the inventory level, although IDMS methodology decides which decision is the best for operation managers. In other words, while SCP is planning the operation on time window, IDMS is deciding which activity is the best among decisions and conducting the right response. IDMS selects best fulfill supply for demand from the disaster area by using SCP planning methods. In theory, SCP planning periods are short-term periods which enclose operational activity, scheduling activity and dispatching rules. Moreover, also in practice, SCP can be implemented in a disaster management system. Nowadays, it has a prevalent consensus that computer and mobile device programming can be programmed for the same purpose. In computer science, main computers systems are commonly serving systems such as web, SQL, and similar server systems. Mobile device software has to be user-friendly interface because of ease of use. If any commodity or goods request from the operation center, the client has to use rapidly this software. The more basic has a software interface, the more efficient and express service outcome for survivors. Mobile IDMS software is generally designed by a computer programmer. They implement a search and finding the shortest path algorithm according to disaster managers who are developing it. The basic search algorithms, such as Breath First or Depth First, were built up by some mathematicians who were living last century. The basic shortest path algorithm was proposed by Dijkstra who is known very famous mathematician and computer programmer. All of two algorithms are carry out in disaster management software properly. Giving an example of the IDMS in DSS algorithm pseudo code framework is proposed, A is a depot, B is a disaster area nodes;

Table 3: DSS Search Pseudo Code

```
Subroutine goods_demand (param-list);
    control the SCP inventory,
if stock empty {
call Search_ Algorithm() to find goods; }
else {
continue; }
    while{
calculate Shortest_Path algorithm between node_A and node_B;
}
    transport goods from node_A to node_B;
    Return transport;
stop;
```

Program algorithms can be incorporated and performed in many ways to success IDMS. In this example, two algorithms are composed of a hybrid algorithm was surveyed and implemented by the author (Macit, 2018). The first part of this survey focuses on SCP and Search Algorithm, and also it solves short-term and operational action plan problem. The other part of the survey is more dense Vehicle Routing Problem that is not relevant to in this paper. In the first part of the survey, any goods demand from the disaster area is controlled by IDMS disaster management system software. This software approach produces short-term operation activity and solved the SCP problem in mobile devices. The search algorithm that is depicted as P is solved with together the SCP that is depicted as S to perform dispatching the goods. Furthermore, DSS logic rules framework can be set up as you can see;

```
OK then
if P^S then
Result is  OK
Done
```

Search algorithm which is showing pseudo codes as you can see helps the SCP to perform dispatching the goods. SCP to calling algorithm is coded by PHP that includes SQL codes. If the inventory level of the goods is not enough to demand, Search Algorithm try to find out the closest goods inventory from where. Not only these algorithms can be implemented in IDMS, but also they can be varied and performed by many other search algorithm approach. In this survey, to find the shortest path, Floyd-Warshall algorithm was implemented. Floyd-Warshall algorithm uses to find the undirected shortest path.

Table 4: Floyd-Warshall Pseudo Code

```
declare int i,j, path[][];
begin
procedure Floyd-Warshall (i,j) : (k)
do until k {
for each (i,j)
path[i][j] := min ( path[i][j], path[i][k] + path[k][j] )
return <- path[i][j] }
stop;
```

There are many technics to reduce inventory and stock level in depot or firms. While inventory control and management technic decrease the firm's stock level, holding costs and handling, the same time the technic conducts goods from supplier to customer best time. These technics can be implemented the same aiming that mentioned earlier methodology to reduce inventory level in disaster management. And also many firms, business to business (B2B) or business to customer (B2C) implements the supplying technics to avoid the financial cost. All of these technics is called supply chain management (SCP). SCP methods can be applied in IDMS to reduce inventory level at disaster operation depot and boosting response and relief serving at the best time to the survivor who needed medical or non-medical goods. To calculating in demand under uncertainty, D_i is mean of the demand and σ_i is the standard deviation of the demand in each period, are distributed in normally TD N(0,1). Total demand TD all of k.th period and its standard deviation S can be shown as formula (1) and formula (2) respectively.

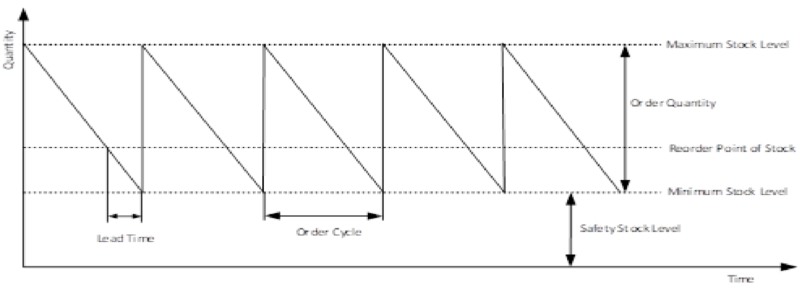


Figure 6: Safety Stock Graph

Inventory level has calculated by these formulas for each order cycle and was coded in SQL database programming language. In formula (2), cov(i,j) is covariation coefficient that explained the correlation between i.th demand and j.th demand. Disaster operation centers have limited inventory capacity. Goods demand that is medical or nonmedical quantity is indeterministic in disaster. Because of stochastic demand, inventory level fluctuates in the disaster timeline. Disaster operations manager should decide to keep the minimum amount of the inventory I level that is known as safety stock. Safety stock SS_i is the minimum amount of inventory to be used during the lead L_i time when stock will be newly replenished.

$$TD = \sum_{i=1}^{k} D_i \tag{1}$$

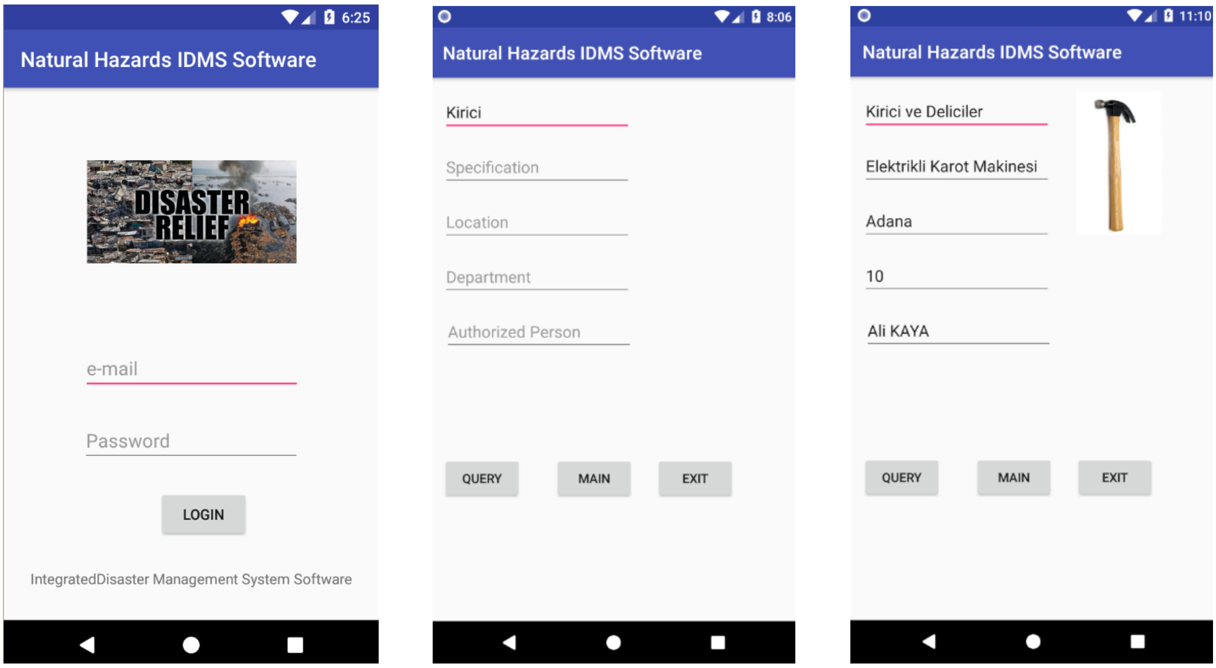
$$S = \sqrt{\sum_{i=1}^{k} \sigma_i + \sum_{i=1}^{k} cov(i,j)} \tag{2}$$

Reorder point, ROP, is the crucial decision of this safety stock to calculate reorder level. The point of the reorder computes as $ROP_i = D_i L_i SS_i$ it shows graphically in Figure 6. SCP determine inventory policy, while IDMS manage goods which demanded by survivors by means of mobile software. Disaster operation center continue to serve for survivors. Moreover, it is expected that the developed algorithm can be solved this kind of problem such as decrease of the inventory level and cost, continue service time and quality, low level inventory budget and fullfil the survivor demand which is medical or non-medical. On the other hand, SCP in the core of the IDMS makes easy the people who are hurt by catastrophe on the time when they need by means of mobile telecommunication systems. In this project, some SCP policy such as reorder point, safety stock level was implemented and coded in SQL and Android Java. While SCP policy controls the stock level under the expecting quantity, at the same time, it acquires agility in disaster management. Since inventory level is the primary impact factor of the cost and service quality, it has to be controlled by management systems. This type of control can be conducted easily by software and computer systems that include appropriate algorithm especially mobile systems in disaster. Developed the dispatching algorithm, stock policy, and software in this research can administrate inventory that of includes non-medical goods and tools in a disaster.

4 Research Finding

In research findings, it would not explain how to mobile program software works, on the other hand, it is focused on what would do DSS and software programming algorithm. Classic disaster management systems manage paper-based management systems. On the other hand, paper-based management systems cannot supply the time demand. On time, demand is very important in disaster management systems. There is no doubt, it cannot be compared classical disaster management and IDMS managing in respect to information systems. The proposed algorithm has been exerted in a mobile devices software that was Android Studio. The user interface was designed simply in order to aim beneficial. If the user demands the additional components that are in the GLIDE database, these components can be added by developers the software menus. To enter the software depicted in Figure 7.a, users have to register to the computer server systems. The client uses e-mail id that is unique in order to log to the system in. It is known that CIT is widely used occurring in a disaster. In another saying way, CIT takes over the key role in disaster management systems. CIT progresses bi-directional in a disaster management, one side is a survivor and the other way is operation managers. The used algorithm should be selected a proper according to a data structure. Data Services at the rigth time and on the time in disaster determines the level of its success. Stock level and its management in a disaster operation center is a very crucial problem. The solution technics has been developed against this kind of problem. And also, mobile software program coding helps to solve this kind of problem. The other problem of the disaster operation center is control of the inventory level. Mobile software and communication systems give us an opportunity to solve some supply and dispatching case. Especially DSS approach is more helpful for supply chain policy than the other intelligent system. The main screen of the software depicts the tool picture to determine the right disaster relief tools. The picture in software assists in selecting the right disaster relief tools Correct tool selecting and inventory level is very crucial to maintain SAR team. Tools that are needing in the disaster area can be found by software in too close and propose sent to the SAR team. When the press the Query button, the developed algorithm runs to find the tool from which is inputted name.

Query screen for goods comes from after the login to IDMS software system. Design of query screen should be very simple to ease of use. There are three buttons on the query screen to do, the first button is to do the query, the second button is back to the main menu, and the last one is to exit the program. When the program is operated, the query button runs SQL commands and it calls DSS algorithm, properly. Simple screen design keeps easing of use and quickly reach



(a) (b) (c)

Figure 7: IDMS software system menus

the information. Goods requested from disaster area shows on the second screen that is query screen on depicted Figure 7.b. Query screen have to have at least five rows that include items specifications. Additionally, it should be at least one picture that displays items what it is. Since tools are confused by some users, the picture on the query screen has to be in there. And at the same time, this picture on the query screen is explaining clearly for the tools. For instance, the hammer is the name of the hand tool for working, and the same time hammer is the tool that has a hydraulic pump to crack stones. The query that results, all of the information about the necessary is displayed in the last screen depicted in Figure 7.c. In the background of this system as a service runs SQL database system, web server system and the programming language that name is Personal Homepage Programming (PHP). When the risk analysis has been completed, the operations managers then can assess its current capabilities the resources available for an actual emergency thanks to IDMS software. Operations manager and agent in the disaster area can access their recover and relief capabilities and control their capacity as an online by IDMS software. Operations manager and disaster agent (such as search and rescue team, official staff, volunteer) in the disaster area can access their recover and relief capabilities and control their capacity as an online by IDMS approach and software. The template to carrying the data for IDMS software was proposed by the author as in JSON format in Fig. 8. In first, data is converted into JSON by Volley software library to carrying over the Internet. Data the reaching to the web server as JSON format convert into PHP variables to querying into the database server. This progress is the most important for the IDMS software because of the critical issue. Converting PHP codes into database codes include the decision-making process. Decision-making process includes some rules developed to find minimum distance (minimum shortest path) from the demand area to supply center. In order to find a minimum shortest path, the mobile software calls an Algorithm that runs Floyd-Warshall. In order to find a minimum shortest path, the mobile software runs an Algorithm that is designed Floyd-Warshall coded in PHP. Floyd-Warshall algorithm does not take into account a directed network in this research, and it accepts all network is undirected. If the directed network tries to solve by means of Floyd-Warshall algorithm, results do not obtain short time. Since undirected network solves easier than the directed network, it prefers the undirected network algorithm. In conclusion, results obtained from the selected method gets easier, and coded in software.

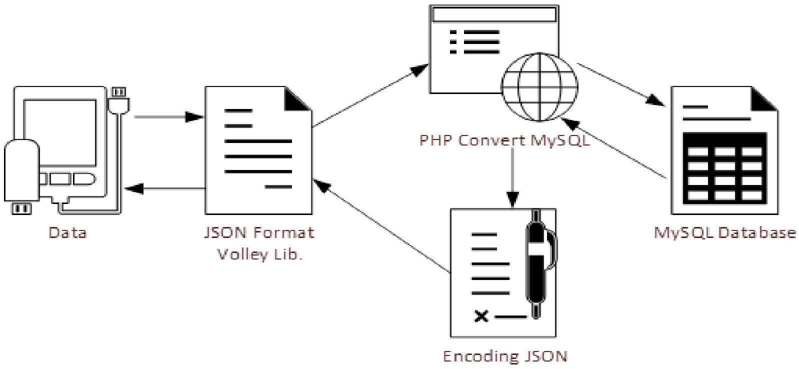


Figure 8: Proposal Designing Data Transmission for IDMS

The decision-making progress in which covers some rules is the core of the IDMS software. These rules help to disaster manager make-decision in which one is the best. The rules to decide for a disaster manager was coded by SQL command in respect to logic propositions. The SQL results from the database were processed by DSS in server systems, and then convert these results into JSON format by encoding. At the end of this process, DSS results from the server were shown on the mobile system. This software which has some capabilities is advanced to the abilities of the operations managers, also. Some information that acquiring from disaster area could be able collected by the mobile device and sent them to the server system to processing for the manager.

5 Conclusion

Nowadays, Computer and information technology progress at all of fields very speedy. And, it can find many applicaion areas. The disaster study area is one of them. A disaster whether is originated by natural or non-natural gives people pain.There are many ways to find the best solution in order to fulfill demand in the disaster area. In giving an example of this problem, it is proposed an algorithm to solve the demand problem of the disaster area with the SCP approach. IDMS that SCP is at the core of it might be best disaster management system. Well-prepared plans thanks to IDMS and software specify what will be done, when, where, and by whom, to satisfy the specific request of the disaster area. By means of mobile software can change SCP policy, moreover, other network algorithms different from Floyd-Warshall can be implemented. Also, this study shows that computer and information technology can be used easily in disaster. In conclusion of this study, there are many benefits of IDMS such as;

i. Inventory stock level could hold low quantity in the disaster management center,

ii. Keeping update the stock level in disaster warehouse,

iii. When a demand occurs for a tool, it dispatches immediately,

iv. Permitting to change the Stock policy of the SCP,

v. Implementing the decision-making (DSS) systems and optimization algorithms on mobile CIT,

vi. Deployment of the effective CIT solution technics.

IDMS approach and this software emphasize an integrated approach to the management of disasters across the full size, including natural, technological and man-made disasters. Although IDMS software in this research is shown in basic disaster relief activity, it can use at all of the disaster types. In the future direction of this study, by using the SCP policy, phases, network and software algorithm might develop for the IDMS.

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