

A Reputation Management System for Efficient Selection of Disaster Management Team

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Abstract— Managing a disaster and emergency situation is a challenging task. Various ICT based systems like the Oasis and SAHANA have been developed in the recent past to provide necessary coordination, collaboration, operational monitoring and resource sharing facilities for different phases of disaster management. As different organizations share their resources and skills in a disaster situation, the concepts related to collaborative networks (virtual enterprises/extended enterprises) become more relevant. Under such conditions, one of the issues is related to the efficient partner or team member selection as applicable in the case of collaborative networks. Although different partner selection mechanisms have been proposed in the literature of collaborative networks, these cannot be applied directly in the disaster management situation. Trust and reputation have been identified as one of the important factors for the efficient disaster management in the related literature. The current work focuses on the development of a reputation management system that can help in the evaluation of different team members for team formation and evaluating the performance of each member in terms of trust. The framework identifies important factors having impact on the reputation and trust of a particular organization working in collaboration with other organizations, proposes an algorithm for calculating the reputation score and finally proposes a Service Oriented Architecture (SOA) to extract information/indicators from information sources and external systems. The system can be applied in team formation and performance management system of various disaster management support tools.

Keywords— disaster; emergency management; reputation; trust; virtual organization;

I. INTRODUCTION

The susceptibility of our planet earth to disasters brings many challenges to the responsible authorities. This stimulates the involved stakeholders to be always in search of innovative solution which can lessen the effects of disasters. A lot of work has been done to make optimal solutions in different domains like management while disaster management has also been in focus in Information and Communication Technology (ICT) since last decade. Various ICT based solutions like SAHANA and OASIS were developed to cope with the turmoil produced by the disasters. The experience of using such kind of ICT solutions in disaster management proves to be very successful.

By witnessing this success, in disaster and emergency situation, in different parts of the world, researchers are trying to propose new ideas in this domain because the prospect of

improvement is still there. Disaster and emergency situation demands collaborative and cohesive efforts to mitigate its effects. To accomplish this, organizations share their resources, knowledge and skills. Since different organizations share their resource, the idea of collaborative networks becomes applicable but this sharing is possible only if they trust each other. Reputable and trustworthy partnership is mandatory in chaos and turmoil. Moreover, considering collaborative nature of the disaster management operations, the organizational form of Virtual Organizations (VOs) seems to be more appropriate mechanism. Partners/team members can be selected from a pool of potential partners to form a temporary alliance where competencies, resources, skills and costs can be shared by the partners to meet a particular market challenge.

However, trustworthy and efficient partner's selection is a challenge. Different partner selection mechanisms like agent-based and multi-criteria decision making, based on trust and reputation, have been devised but these cannot be directly applied to disaster management and emergency response situation. Since trust and reputation have been identified as one of the important criteria for efficient disaster management so this work focuses on the development of a reputation based trust framework for team formation and evaluation of each member in terms of trust and reputation.

Rest of the paper is organized into three sections. Section II presents background study and related work in the domain of disaster management, trust and reputation management and virtual organizations. In Section III, the proposed framework is introduced while in the Section IV, paper is concluded with the implications of the future work.

II. BACKGROUND STUDY & RELATED WORK

Disasters are unforeseeable and bring chaos in the affected area. Indian Ocean Tsunami 2004, Pakistan's Earthquake 2005, Myanmar's Cyclone 2008 and China's Earthquake 2008 are few examples of recent past disasters. The death toll in these disasters was approximately 603,712 besides infrastructure and other financial losses [1]. Coping with such kinds of disaster and emergency situations is a tedious and multifaceted task. It not only demands humanitarian relief but also financial support depending upon the scale of the disaster.

To handle these problems, different phases of disaster management (DM) have been defined. These phases are grouped into Preparation & Planning, Response, Recovery and

mitigation [2]. These phases have facilitated the better performance in the disasters and emergency situation.

Besides these phases, the support of ICT in disaster management appears to be a blessing which has helped not only in managing resources but also in saving human lives. SAHANA is an example of it. It is Free and Open Source Disaster Management System which has a modular and flexible framework having different features, set of libraries and APIs. Core modules are Organization Registry, Missing Persons Registry, Request Management System and Shelter Registry [3],--, [5]. Different products are developed under SAHANA Software Foundation which include Eden, Vesuvius and Mayon [3], [5]. Different relief and rescue organizations like City of New York's Office of Emergency Management, Taiwan project at Academia Sinica, the Sri Lankan Government's National Disaster Relief Services Center, the Philippine Red Cross and the International Federation of Red Cross Societies' Asia Pacific Region are getting benefit from SAHANA [4]. In addition to this, SAHANA has been used in Venezuela, Haiti, Chile, Pakistan, Bangladesh, Japan, China, India and Sri Lanka for disaster response [4], [5].

The Oasis is another project which is funded by European Commission. The purposes of the Oasis are situational awareness through ease of communication, collaborative planning and tasking, operational monitoring, decision making and resource sharing in an emergency situation [2], [6]. For these purposes, three modules are defined which are IT Framework, Operational Tools and the Tactical Situational Object (TSO) [7]. TSO is a standardized and simple way of information exchange among emergency responders from up and down the command hierarchy [7], [8]. By using IT standards, the Oasis resolves security issues, incorporates legacy systems and handles large number of networks hence making a significant support for rescue and relief organizations [2], [6].

VO is a form of collaborative network in which skilled and competent partners are selected for temporary alliance. This alliance enhances competition and gives an opportunity to the partners to share their core competencies in terms of resources, services, knowledge and skills [9]. The advantage of VO is sharing of resources and skills by different organizations to meet a particular market challenge or an opportunity which cannot be achieved otherwise by any of the individual organization. The lifecycle of VO has four phases which are identification, formation, operational and dissolution [9]. In the identification phase; opportunities, objectives and goals are identified. In the second phase, partners are identified, evaluated and selected. In the third phase, operations are carried out to meet the objectives and goals. When the goals are met, team is dissolved which depicts the last phase of the lifecycle. The concept of VO has been widely exploited in fields like ecommerce and science-projects. It has been established that VO has saved time and cost in these fields but the concept of VO is not appropriately utilized in DM.

Trust is a subjective phenomenon and associated with face to face communication. Due to its complex nature, it has been

in focus in different fields which include sociology, psychology, economics, and philosophy and now in ICT since trust leads to confidence in others [10]. P. Sztompka describe three aspects of trust; first is relationship, second is related to psychology whereas third involves culture [11]. The author also stresses that in the presence of trust, transaction cost decreases while the probability of the cooperation increases [11] where as the absence of trust results into higher risk and vulnerability which further leads towards conflict [10]. Reputation is the assessment of trustworthiness of the subject entity. It is based on the ratings or recommendations from the underlying community. Good reputation fosters trust. Trust and reputation have been identified as one of the important factors in online and virtual communities like social networks, e-commerce, and VOs. Trust and reputation are mandatory for effective performance. Trust has been studied from different perspectives and has been categorized into five types [12].

In DM case, trust is more important as DM also involves social, psychological and economical issues. Besides this, the responding organizations have different organizational, cultural and social background. These aspects may obstruct the coordination and collaboration efforts while responding to disasters whereas promoting trust in emergency and relief organizations results in better attitude, high performance and strong coordination. By trusting each other, team members show the willingness to depend one another for completing their common goals. Since teams are formed quickly in an emergency situation and realizing the importance of trust, Zolin has conducted an extensive research for fostering trust in quickly formed teams. He suggested swift trust as a key to attain collaboration in swiftly formed temporary teams [13]. Another researcher has portrayed trust as a catalyst for interagency coordination and collaboration in disaster response operations [14]. A trust model based on SECURE Framework for emergency response information repository system has been proposed [15]. Another study on the virtual emergency operation centers showed the trust as a crucial aspect in decision making [16]. Although there has been some focus on reliable and true information during disaster and emergency situation but trust and reputation framework for team formation and evaluation needs particular attention.

VO is goal oriented and partners are geographically distributed that have not usually met each other face to face [12]. Trust under such conditions, has significant impact on the performance of temporary teams [10]. Several mechanisms for measuring trust and reputation have been proposed in different contexts. Mun et al. proposed a trust model based on project constraints and strategies in which trust value is the probability that a goal is satisfied by the trustee when the task is completed [17]. Another research emphasizing on the necessity of trust establishment in the formation of a virtual organization has been performed in which trust negotiation was presented as a way to select best possible partners in virtual organization [18].

In a disaster and emergency situation, resources are usually limited and hence precious. It is also observed that single organization cannot handle large scale disasters because of

shortage of resources, capabilities, knowledge or skills. In such a situation, it becomes obligatory to select reputable partners for better disaster management. Here the concept of VO becomes relevant since the temporary coalition of competent partners will ensure efficient usage of resources, skills, knowledge and experiences. The assessment and evaluation of a potential partner is a challenging problem. The potential team members' evaluation in the team formation and performance measurement in terms of trust/reputation in actual experience can be the solution to this problem. A large number of trust and reputation models related to collaborative networks are proposed but these cannot be directly applied to the disaster and emergency scenarios since the context of the trust is dynamic. For example, people can trust a dress designer for their dress design but not for their home design.

The next section, describes in detail the proposed Reputation framework for disaster and emergency response operations to meet the above mentioned challenges.

III. REPUTATION FRAMEWORK

This work focuses on the reputation management of the partners in pre, during and post disaster management activities. For this, trust and reputation factors are identified based on the existing disaster and emergency response protocols, standards, frameworks and other related published work. The knowledge and experience of different disaster and emergency organizations like The United Nations International Strategy for Disaster Reduction (UNISDR), Federal Emergency Management Agency (FEMA) of the US Department of Homeland Security, National Disaster Management Authority (NDMA) of Pakistan, National Emergency Management Association (NEMA) of the US, Asian Disaster Reduction Centre (ADRC), National Institute of Disaster Management (NIDM) of Pakistan, Program for enhancement of Emergency Response (PEER), National Incident Management System (NIMS) of US, Collaborative Agencies Responding to Disasters (CARD), International Federation of Red Cross (IFRC) and SAARC Disaster Management Centre (SDMC) have been considered. In addition to this, the issues related to collaborative networks and virtual organizations are also considered.

An endeavour by the NEMA, FEMA and other emergency management agencies of US is the Emergency Management Accreditation Program (EMAP). It has identified thirty different categories of disaster response operations [19]. Among these, twelve categories demand collaboration from different organization while others are related to emergency and disaster administration.

The identified factors and indicators for reputation management in emergency and disaster management are connected to these operational categories since every category will require its specific resources, skills and knowledge while the Oasis' three hierarchical levels for disaster and emergency management are utilized which are strategic, operational and tactical [2], [6]. Strategic level depicts command and control level of the organization, operational level manifests operational teams and this can be divided into geographical

and functional sectors. The third level shows front line or ground level [6]. This tiered approach will help in better management of trust and reputation since at these levels, trust/reputation is managed.

The proposed Reputation Framework for disaster and emergency response operations can be divided into two major components: 1) Reputation Meta model & Reputation Indicator Matrix 2) Services & Information Exchange Mechanism 3) Computational Algorithm. Reputation Meta model classifies important reputation indicators that can be used for trust management before and during the disaster operations while the reputation indicator matrix tries to establish the relationship of these indicators with various competencies and capabilities of potential partners or team members. Services and Information Exchange Mechanism defines web services for extraction of information and indicators. Computational Algorithms describes the process of computing the reputation score. Further details of the proposed framework are as follows.

A. Reputation Meta Model & Reputation Indicator Matrix

Considering the disaster management lifecycle, the phases of the cycle are divided into two groups. One is called 'Before disaster/Pre-disaster' which include 'Preparation and Planning' phase. The other is 'during & After/post Disaster' in which Response, Recovery and Mitigation phases are incorporated. The identified factors are associated with these two groups. Some of these factors have their own sub-factors as well. The Meta Model for Reputation Indicator (RI) is shown in the Figure 1.

In the Pre-Disaster category, since Preparation and Planning are involved which requires to foresee and predict the trustworthiness of the potential partners if they have not worked before with the subject Disaster Management Authority (DMA). For this, different criteria are proposed in this framework. The first one consists of standards which are defined for different emergency response categories like SPHERE Standards for NGOs and Humanitarian Accountability Partnership (HAP) Standards. Following such types of standards is one of the evidences of the potential partner's competency and hence trustworthiness [20], [21]. The other factor, which helps in building trust, is the group of courses and workshops offered by different disaster and emergency management agencies. By this, the stakeholders who have attended the workshops and courses are obviously more reliable since they have more knowledge and skills about a disaster and emergency situation. UNISDR, NIDM, FEMA, NIMS and PEER offer courses and conduct workshop for this purpose. Another reputation indicator consists of the Exercises and drills. It is also very important and should be encouraged since people get trained and familiar with the hazardous conditions [14], [20], [21]. Moreover, they meet face to face and do collaborative efforts hence trust builds among themselves [14]. This indicator is also endorsed by different agencies like UNISDR and FEMA. Mutual Aid Agreement (MAA) and Memorandum of Understandings (MoUs) are significant tools. FEMA, NDMA, ADRC and SDMC give importance to them. By signing MoUs/ MAA

with DMA, partners formalize their relationship which shows their trustworthiness on each other. Another factor, the Previous Experience in the related operational category plays an important role in establishing trust [22]. In case of having partnership in past, Previous credibility of the partner also matters. Another important RI is the related Operational Resources. This is also supported by Currao, Hyogo and NDMA's Framework [14], [20], [21]. Similarly, partners having any sort of collaboration with different organizations at local levels are capable enough to be trusted [20], [21]. Equipment certification can also be criteria for being a trustworthy and reputable partner since emergency situation cannot afford low quality equipment and machinery.

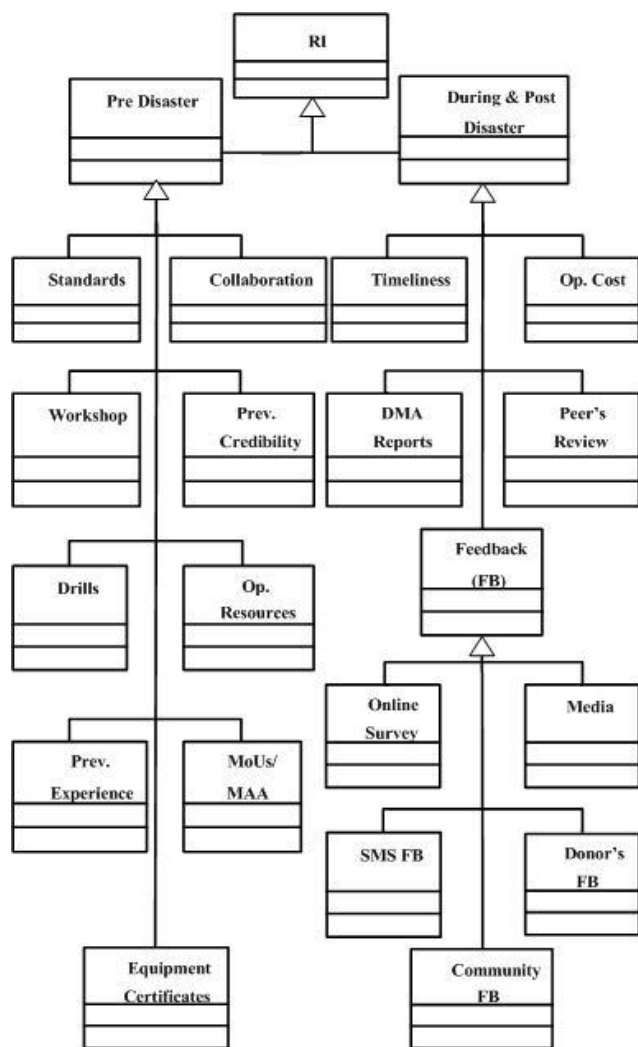


Figure 1. Meta Model for RI

During and Post Disaster category gives an opportunity to evaluate and assess the reputation of the partner while they have actually performed on the ground. Timeliness and Operational Cost are important factors since timely response and efficient usage of the precious resources manifest partner's competency and skills [20], [23]. Peer's review is also very important as they are in better position to judge the performance [23]. Feedback by different stakeholders will

give better picture of the partner's performance and attitude in an emergency situation [23]. Feedback from donors, affected population, communities and media helps in better judgment [20], [24], [25]. It also gives better view of reputation value computed in the Pre Disaster Category. In addition to this, surveys are also very helpful [20]. Online surveys can be conducted to evaluate the reputation of the partners. Moreover, Disaster Management Authority/Agency's evaluation report about a partner's performance also reflects the reputation of the partner.

For partner selection, it is also important to consider their core capacities whether institutional, organizational, technical or technological. These can also be in terms of Financial, Organizational, Operational, External or Third party [23], [26]. Financial depicts financial aspects, Organizational manifests organizational stability, Operational shows functional reliability, Third Party describes about the recommendations and External points towards factors external to the organization [26]. By the addition of the Capacity/Competency in this classification, it is Called FOOTEC. The relation of two sets of reputation factors with this classification is shown in the form of matrix in table 1.

TABLE 1. Reputation Indicators Matrix

Reputation Indicators		Type					
		F	O	O P	T	E	C
Before Disaster	Standards				Y		Y
	Exercises, Drills			Y			Y
	Workshop, Courses, Certificates				Y		Y
	Equipment Certification				Y		
	Mutual Aid Agreement		Y	Y			
	Previous Experience in the related field		Y				Y
	Operational Resources	Y					Y
	Any sort of collaboration with government/non-governmental institutions at local level		Y	Y			
	Previous credibility of a partner		Y				
During & After Disaster	Timeliness			Y			Y
	Operational Cost			Y			Y
	Feedback		Y		Y	Y	
	Peer's Review				Y	Y	
	DMA Evaluation Reports	Y	Y	Y	Y	Y	Y

B. Services and Information Exchange Mechanism

So far, we have discussed the conceptual model of the reputation framework for disaster management. However, the required information for each of the above mentioned indicators needs to be maintained and monitored efficiently so that effective decision making can be done under the chaotic situation of an emergency. For this purpose, an effective ICT solution is also required. Specially, the information exchange

should allow interoperability of heterogeneous systems that will be in place by different organizations. Depending upon the information or indicators, a Service Oriented Architecture (SOA) can help in evaluating the reputation in terms of capabilities, skills, knowledge and resources of the potential partners and then gives the prioritize list of the partners.

Therefore, SOA architecture for the purpose of information exchange and reputation calculation is purposed as shown in the figure 2. There are two components of the internal system. 1) Criteria collection, compilation & aggregation that extract, compile and aggregate the information/score of the factors/criteria 2) Reputation manager that anticipates and then calculates the overall reputation score by including the post disaster criteria score. The significance of reputation anticipation is that if a new entry has not performed on ground then its reputation can be anticipated while after performing in a disaster, actual reputation can be calculated by adding anticipated reputation in the score of post disaster criteria. Actual reputation is also based on the performance of the partner in a task assigned to it in a disaster and emergency situation.

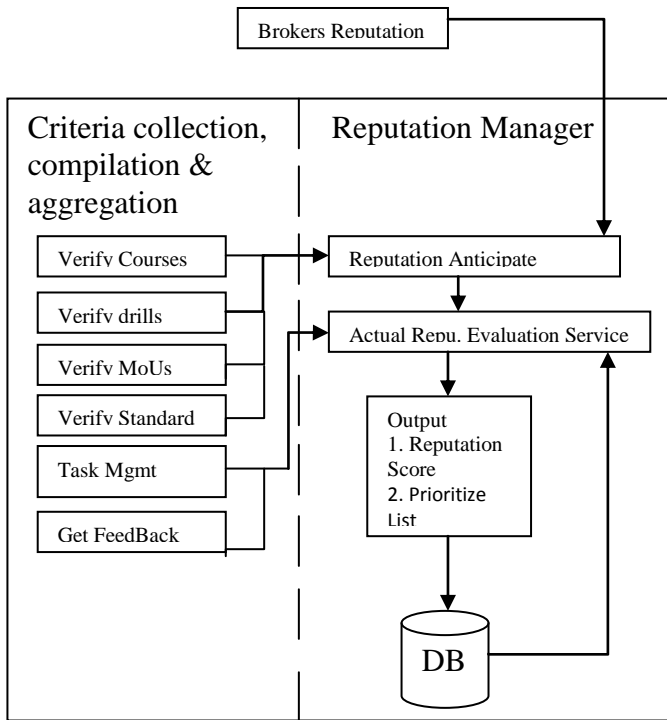


Figure 2. SOA for Efficient Disaster Management Team Selection

C. Computational Algorithm

Different Mathematical Techniques for Decision Support Systems (DSS) are devised. Some of these techniques are based on Sum and Mean Model, Flow Network Model, Bayesian theory, Fuzzy Logic, Markov Model and Multi-Criteria Decision Making (MCDM). MCDM is very popular and used in different domains like financial analysis, housing assessment and disaster management [27], [28]. Different Integrated techniques are also developed to overcome the shortcomings of one another.

In the proposed Reputation framework, Reputation for each factor is calculated by using simple sum and mean methods. Feedback is collected, aggregated and disseminated. The Amazon, the eBay, BizRate and the epinions prefer these methods [28, 29]. However, our research is still underway to find an effective computational model for reputation calculation to balance out any biased found in the reputation indicators. Following Algorithm gives the summary of the calculation method.

1. Get the disaster type as different disaster types demands different capacities, resources and skills
2. Get/check the weightage of the factors
3. Get the degree of satisfaction of all pre-disaster factors to anticipate the reputation
4. Get the sum and mean 'δ' for each factor
5. Now apply the following model to aggregate the value of each factor depending on the weightage of the criteria

$$\rho(f_n) = \omega_n \delta$$

$\rho(f_n)$ indicates the aggregated reputation value of a factor f_n , ω_n represents the weightage of that factor while δ represents degree of satisfaction of a factor by a particular partner.

6. Check the reputation of the subject entity in the broker database (if it exists).
7. Now calculate the anticipated reputation by summing up the calculated values of the factor
8. Task is assigned to each partner and a unique id is assigned to this task.
9. When the partner has actually performed on the ground then get the values of post disaster factors for each assigned task
10. Repeat the step 5
11. Now add the anticipated and actual reputation scores.
12. Normalize the final reputation score using z-normal distribution.

For prioritized multi criteria decision making in which the final score depends on the satisfaction of higher priority criteria (lower priority criteria have negligible effect on the overall reputation score) can also be calculated using the mathematical model proposed in the [30].

IV. CONCLUSIONS

In the real world scenario, people start trusting each other when they meet face to face and this happens gradually. Besides this, some sort of documents, certificates and relevant resources are also the source of establishing reputation of an individual or organization. In this research, the same techniques are applied because in the very first stage, it is difficult to trust on a partner especially in case of disaster and emergency situation. The factors of Pre-disaster category are the source of anticipated reputation of a partner. While the factors of during & post disaster category are the source of actual reputation since the partners have actually performed in the emergency situation and relevant stakeholders give feedback. Moreover, a Service Oriented ICT Model has been

proposed in which the relevant information or indicator measures can be extracted from different information sources and external IT systems. Hence it ensures interoperability of heterogeneous systems.

The proposed reputation framework will be enhance in future with a robust computation model that can balance out any biases in the feedback given by different users or any tradeoffs that exist in the reputation indicators.

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