

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 to provide necessary 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 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 but considering the dynamic context of trust, 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 for efficient selection of disaster management team. For this, a framework identifies important factors having impact on the reputation and trust of a particular partner working in collaboration with other organizations, proposes a Service Oriented Architecture to extract information from information sources and finally proposes an algorithm for calculating the reputation score. 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 (DM) 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 as trust is dynamic in context. 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 results and implications of the future work.

II. BACKGROUND STUDY & RELATED WORK

Disasters are unforeseeable and bring chaos in the affected areas. 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 DM have been defined. These phases are Preparation & Planning, Response, Recovery and mitigation [2].

ICT tools have been used during these phases and have been extremely helpful. 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 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 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 a European Commission funded project for 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], [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]. Sztompka describes 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] whereas 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. An extensive study of trust and its categorization is discussed in [12].

In DM case, reputation/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. She conducted ethnographic observation, questionnaires and structured interviews and 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. He deduced this by conducting interviews with senior officials and officers from various DM related agencies [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 a task is completed. This research is based on mathematical model and exemplary scenario [17]. Another application scenario based research emphasizing on the necessity of trust establishment in the formation of a VO has been performed in which trust negotiation was presented as a way to select best possible partners in VOs [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 research methodology followed by the existing work includes ethnographic observation, questionnaire, interviews and case studies in disaster management literature [13]--[15] whereas mathematical models, scenarios and applications were used for VOs related literature [17], [18]. For the current work, reputation/trust factors are identified and deduced based on the existing disaster and emergency response protocols, standards, frameworks and other related published work. The identified factors and proposed framework was verified and improved through surveys and feedback by actual stakeholders i.e., different disaster management organizations and NGOs. 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. 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, National Disaster Management Authority (NDMA) of Pakistan, National Emergency Management Association (NEMA) of the US, Asian Disaster Reduction Centre (ADRC), Program for Enhancement of Emergency Response (PEER), National Incident Management System (NIMS) of US, Earthquake Reconstruction & Rehabilitation Authority (ERRA) of Pakistan, 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 VOs 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 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. 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 three 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 reputation/trust management before, during and post 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 from different sources. 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 Indicators (RI) is shown in the Figure 1.

Pre-disaster category deals with preparation and planning activities for which the collaboration of a potential organisation with a concerned disaster management agency has an impact on reputation. For this, different criteria are deduced 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 level of preparedness to complete a particular job [20]--[22]. Training for the enhancement of the participating organisation's competency and skills is another factor affecting trust and reputation. UNISDR, NIDM, FEMA, NIMS and PEER offer courses and conduct workshop for this purpose. Exercises and drills is another important indicator as this encourages people to get trained and familiarise with the hazardous conditions [14]. Moreover, they meet face to face and do collaborative efforts hence trust builds among themselves [14]. Mutual Aid Agreement (MAA) and Memorandum of Understandings (MoUs) are significant tools for DM. FEMA, NDMA, ADRC and SDMC give importance to them and sign MoUs for DM. 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 [23]. Broker reputation is the reputation score computed by other DM agencies. It is valuable to consider it. Other factors include local

collaboration of organisations [14], [20] and equipment certifications.

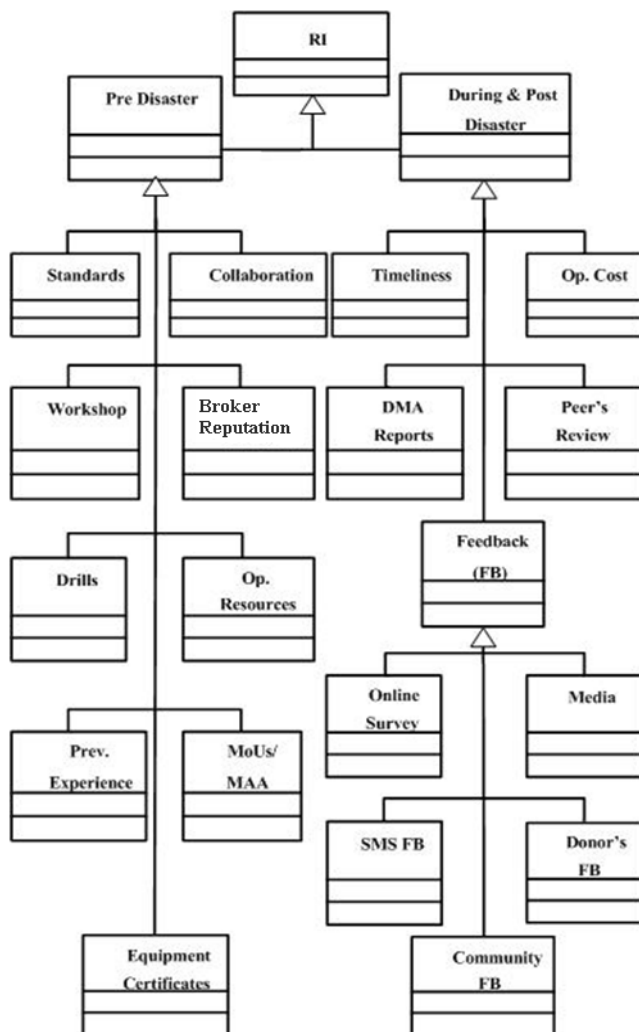


Figure 1. Meta model for RI

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. These are used for evaluation in [20]. Feedback by different stakeholders will give better picture of the partner's performance and attitude in an emergency situation. Peer's review is recommended in [22]. Feedback from donors, affected population, communities and media helps in better judgment as mentioned in [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 as recommended in [20]. Online surveys can be conducted to evaluate the reputation of the partners. SMS can also be another mean to get feedback. 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 competencies whether institutional, organizational, technical or technological. These can also be in terms of financial, organizational, operational, external or third party [26], [27]. Financial depicts financial soundness, organizational manifests organizational stability, operational shows functional reliability, third party describes about the recommendations and external points towards factors external to the organization [27]. 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 INDICATOR MATRIX

Reputation Indicators		Type					
		F	O	Op	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			
During & After Disaster	Broker Reputation		Y		Y		
	Timeliness			Y			Y
	Operational Cost			Y			Y
	Feedback		Y		Y	Y	
	Peer's Review		Y	Y			Y
	DMA Evaluation Reports	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.

A Service Oriented Architecture (SOA) for proposed reputation management system is suggested so that information exchange from heterogeneous systems can be made. The proposed system architecture is shown in Figure 2. There are two components of the 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.

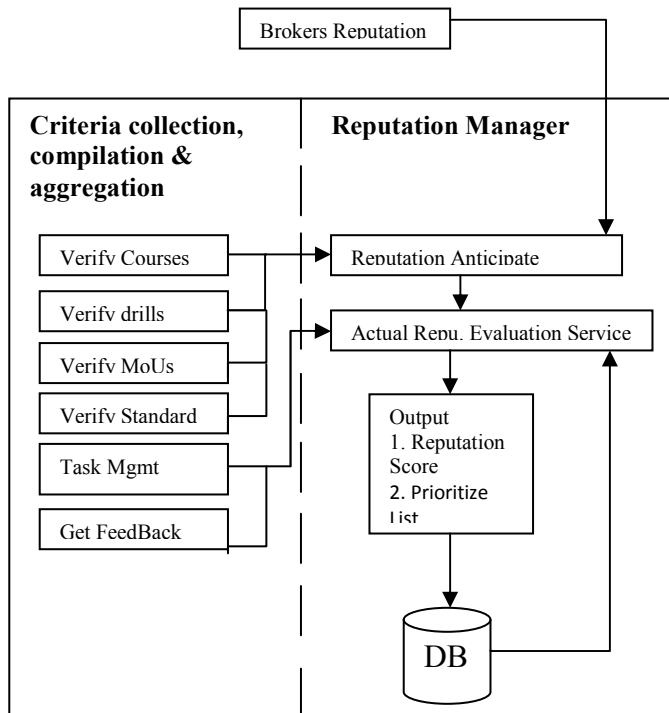


Figure 2. SOA for efficient disaster management team selection

C. Computational Algorithm

Different mathematical techniques for decision support based on multiple criteria have been proposed. 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 [28], [29]. 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 [29], [30]. However, our research is still underway to find an effective computational model for reputation calculation to balance out any biases 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 weight assign to the factors

3. Get the degree of satisfaction/reputation score of all pre-disaster factors to anticipate the reputation
4. Get the sum and mean 'δ' for each factor's degree of satisfaction/reputation score
5. Now apply the following model to aggregate the value of each factor depending on the weight assign to the criterion

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

$\rho(f_n)$ indicates the aggregated reputation value of a factor f_n , ω_n represents the weight assign to 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 factors
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 reputation scores of post disaster factors for each assigned task
10. Repeat the step 2-5 for post disaster factors.
11. Now add the anticipated and actual reputation scores.
12. Normalize the final reputation score like 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 [31].

IV. RESULTS AND CONCLUSIONS

In this research, we identified that reputation based trust is an important factor for efficient disaster management. It was also highlighted that there is a lack of ICT based reputation system for disaster management. To deal with this challenge in disaster management, a detailed study of publication material of different disaster management agencies was carried out. The factors for reputation and trust were identified and a framework based on this framework was proposed. To evaluate the efficacy of the proposed framework, a survey was carried out to get feedback from renowned disaster management organizations. These include UN, NDMA, ERRA and Engineering Directorate from Pakistan, Concern and FOCUS (international humanitarian NGOs). The respondents agree that all the identified factors are helpful in evaluating the partners based on reputation except SMS FB. The summary of survey results is shown in the Table 2.

The use of VO concepts in disaster management can greatly enhance the collaboration among different partners in a disaster management operation as they share each others skills and resources to fulfil their humanitarian obligations. The partner selection based on reputation and trust and recalculation of reputation based on the During and Post Disaster activities helps in maintaining an updated reputation score. Aggregated reputation score is a vital piece of information for future decision making.

The loosely coupled services of the Reputation Management System can easily be incorporated with the existing systems that ensure interoperability of existing information systems.

TABLE 2. SUMMARY OF SURVEY RESULTS

Pre-Disaster	Importance	Post-Disaster	Importance
Standards	Extremely Helpful	Timeliness	Extremely Helpful
Exercises	Extremely Helpful	Community FB	Extremely Helpful
Workshops	Extremely Helpful	Operational Cost	Moderately Helpful
Operational Resources	Extremely Helpful	Peer Review	Moderately Helpful
Broker Reputation	Extremely Helpful	DMA Report	Moderately Helpful
Previous Experience	Extremely Helpful	Survey	Moderately Helpful
MoUs	Moderately Helpful	Media Reports	Moderately Helpful
Equipment Certificates	Moderately Helpful	Donors FB	Moderately Helpful
Other Collaborations	Moderately Helpful	SMS FB	Neither helpful nor unhelpful

A prototype implementation is under development as a proof of concept. The deduced factors are not yet regarded as exhaustive. More factors will be identified and revealed in future work. Moreover Risk Management perspective can also be incorporated in the proposed reputation framework. A robust computation model can also be introduced 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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