ICT driven Resource Mapping & Triggering using 3Cs for Disaster Management

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Abstract–Disasters are mostly categorized and analyzed by their cause i.e. Natural, Man Made or by generic names i.e. Earth Quake, Tsunami, Flood, Fire etc. but very rarely by their consequences & effects. Further it is evident from history that the losses incurred and the damages made were varied drastically even when the disaster of the same kind occurred. So it will be more appropriate to classify and parameterize the disaster by its consequences & effects in order to develop the comprehensive management plan for the same.

Conventional methods are still not capable to plan in advance the effective systems to timely handle the emergency situations. For years ICT has been deployed for the flow of information during implementation and recovery phase and not for developing systems during planning phase.

This paper defines disaster categories based on various parameters and presents mapping of various resources to these diverse emergency conditions in a time cycle. Importance of social factors like 3Cs i.e. Collaboration, Coordination & Cooperation for ICT based Orchestrization is also described for the timely and efficiently execution of relief operations by different agencies.

Keywords–Disaster Management, Disaster Assessment, Resources, Collaboration, Coordination, Cooperation, Parameterization, Mapping, Orchestrization, Response, Recovery, PAI Architecture

I. INTRODUCTION

Diversified emergency situations have alarmed the society to give great emphasis for development of technological tools to conquer it [1]. Lots of efforts and approaches have been made like web based application for resource networking with limited access to equipment, human resources and supplies [2]. Use of GIS and other communication technologies are giving rise to new forms of ICT [3]. Networking, device configuration, resource scheduling, analyzing existing framework related design challenges for an integrated communication and information systems have been addressed [4] signifying need to develop new models and techniques to coup up with unpredictable nature of disasters [5].

It is also observed that due to technological and hierarchical barriers the agencies involved in the emergency management cannot cooperate efficiently and there is a serious problem of coordinating the events. This gave rise to develop a unified model of orchestrization[6]. This is an attempt to design and implement an open service oriented software architecture that will improve the interoperability among actors involved in multi-risk management, supported by DDMIN (Decentralized Disaster Management Information Network) system using rapidly deployable mobile computing and wireless communication technology for coordinated relief operations [7], describes a techno-management road map to employ ICT for Disaster Management where the attempt is more focused towards the system development with conventional approach, keeping ICT in the center like ad hoc networking solutions, protocol, reliability of system etc. The effort is motivated from the conventional approaches of Enterprise Resource Planning (ERP) etc.

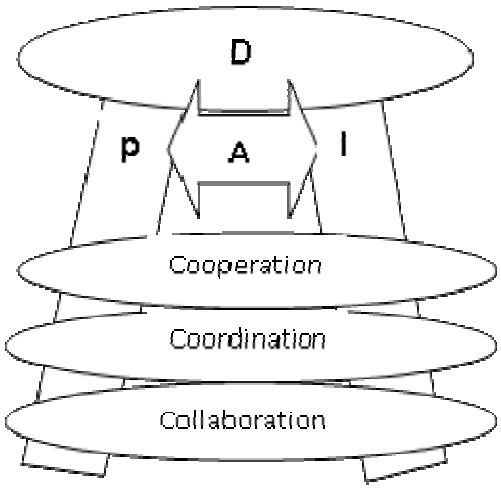

Figure 1. PAI Architecture with 3Cs for DM

New methods of social system design are also emerging [8]. Aspects like Coordination and Cooperation among actors for successful execution of events are proposed. However, the approach models these aspects as the communication complexity only. We feel that if ICT is properly used to model such systems in a more structured way, the performance could be improved reasonably high. Therefore, we propose to improve this design further.

II. PROPOSED ARCHITECTURE

In our earlier work the concept of PAI architecture [9] was proposed where "P" stands for Planning, "A" for Adoption and "I" for Implementation. The disaster is not looked as hierarchical but as explained in fig. 1.

Now to develop this methodology, the disasters are parameterized by their causal effects. The contexts and the aspects are identified as parameters to assess the disaster. Further the impact and severity of these parameters are scaled as Low, Medium and High. Depending on these factors the various types of disasters from D_1 to D_N can be defined as explained in table.1

In Table 1 the parameters are categorized as the effects of adversity because ultimately the role of disaster management plan is first to understand the situation and then to act accordingly by team formation, assignment of task and mobilization of resources.

Now ICT can help in analyzing the disaster type and to assess the detailed resource requirements for its recovery. The entire disaster management cycle can be considered as period T which is consisting of various time segments from T_1 to T_k.

Table 1. Disaster Classification According to their Consequences

Disaster Type / **Disaster Parameter**	**D(n)** → / **P(i)** ↓	**D_1**	**D_2**	**D_3**	**D_4**	**D_5**	**-**	**D_N**
Time of Occurrence	P(1)	L	L	M	H	L	-	L
Location	P(2)	H	M				-	L
Area Coverage	P(3)	M	H				-	H
Climatic Condition	P(4)	L					-	M
Population at Risk	P(5)	M					-	L
Infrastructure at Risk	P(6)	M					-	H
Fire	P(7)	M					-	M
Damage of Utilities							-	
(a) Electricity	P(8)	L						L

(b) Water		P(9)	H						L
(c) Road		P(10)	M						M

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$$D_n = \prod_{i=1}^{m} wP(i)$$

(Where w is the weight/intensity i.e. L for low, M for medium and H for high.)

So now in order to understand the resource mobilization let us assume that we have j no. of resources i.e. from R_1 to R_j. The resources may be fire fighters, hospitals, ambulance, transportation, shelter, food, ad hoc network, broadcasting, software, equipments etc.

Now it is again role of ICT to trigger the required resources at the appropriate time to effectively and efficiently handle the adversity. It is also obvious that no. of resources required to trigger at a particular moment may vary from 0 to R_j as shown in the Table 2.

Table 2. Allocation of Resources on the Disaster Management Time Cycle

Time / *Disaster*	T_1	T_2	T_3	T_4	T_5	T_6	T_K
D_1	{R_2,R_3,R_6,R_9,R_{10}}	{R,R,R,R}	{R,R,R}		-	{R,R,R,R}	{R,R,R}
D_2	-	{R,R)	{R,R,R}	{R}		{R,R,R}	{R}
D_3	{R_1}	-	{R,R}	{R}	{R,R}	-	
D_4	{R_2,R_4,R_5, R_7}	{R}		{R,R,R,R}		{R}	{R,R,R}
D_5	{R_1,R_2}	{R,R,R,R,R,R}	{R,R,R}	{R,R,R,R,R,R}		-	
D_6	{R_3,R_4,R_6}	-	{R,R,R}		-	{R,R,R,R}	{R}
-	-	{R,R,R,R,R,R}	{R,R}	{R}	{R,R,R}		
D_N	{R_5}	{R,R,R,R}	-	{R,R,R}	{R}	{R,R,R}	{R,R}

The Table 2 clearly shows that every disaster is having a unique set of equations for resource allocation.

$$D_n = \int_{K=1}^{s} T(k) \sum_{j=1}^{u} R(j)$$

Now to address disasters in a fast and highly efficient manner, the optimal provision of information concerning the situation forms an essential pre-requisite. This highlights the need for Inter-Resource Orchestrization using 3Cs i.e. Collaboration (C_l), Coordination (C_d) and Cooperation (C_p) [10].

In order to execute the required task all the resources triggered at a particular moment will have different set of rules. Some of them may require to collaborate, some of them to coordinate and some of them to cooperate in order to accomplish the desired goals. These can be picturised by the following fig.

We have assumed that for disaster "D_1"six resources are required to trigger at time frame "T_1"with following requisite:

- R_2, R_6 ⇨ C_l
- R_3,R_9 ⇨ C_d

- R_{10},R_{15} ⇨ C_p

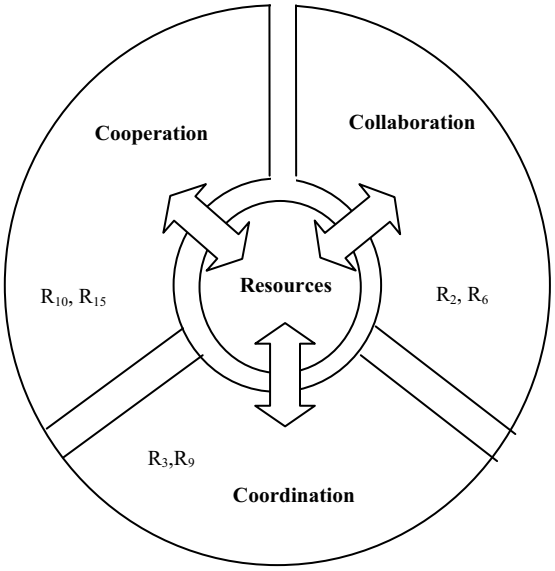

Figure 2. Resource Orchestrization using 3Cs

$$D_n = C_l \int_{k=1}^{s} T(k) \sum_{j=1}^{u} R(j) \oplus C_d \int_{k=1}^{s} T(k) \sum_{j=1}^{u} R(j) \oplus C_p \int_{k=1}^{s} T(k) \sum_{j=1}^{u} R(j)$$

In this manner ICT can be utilized as a drivingforce for Disaster Management. Through thisorchestrization of the overall action plan, timely attackon disasters and its recovery can be achieved

III.ISSUES AND CHALLENGES

It could be pointed out here that the past experience and conventional communication infrastructure & methodology alone does not ensure efficient and effective disaster management[11].

The existing Disaster Management (DM) approaches are quite unstructured and are usually centralized in nature with the instructions flowing from some sort of fixed hierarchy. This results in the poor resource management and hence causes inefficiency& ineffectiveness at the end.Forentire emergency plan to be most effective, the actors and activitiesshould develop trust to confirm well collaborated, coordinated and cooperated approach [12].

Now, there is a challenge to extensively define (a) the scope of parameters & classification of disasters and (b) resource generation &their mapping in terms of 3Cs using Information & Communication Technologies at every stage.Other issues regarding authorization, information flow, transparency, trust, crossing boundaries, priority, skillsetc. are to be recognized distinctively.This indicates the need for a more structured ICT approach for implementing the techniques of project management of this type as

IV.CONCLUSION

In this paper we have extensively reviewed the literatures and it is clearly evident that there is lots of work to be done to make ICT as more effective “Driver” in Disaster Management.

The Emergency Management cannot be confined in fixed sets of rules on the contrary it demands multifaceted approaches because every emergency is “unique”. Therefore the disaster management plan and its execution should be adaptive to the situation. Thus flexible and reliable ICT solutions should be developed to overcome these issues.It is also felt that ICT circumvents these issues and reduces the complexity to a large extent.

Although there is much left to be done. We hope that the perspective and the roadmap suggested here will help build ICT tools that enable us to utilize the technologies effectively and efficiently for Disaster Management.

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