An Approach towards a Decentralised Disaster Management Information Network

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Abstract. The existing Disaster Management (DM) approaches are quite unstructured and are usually centralised in nature with the instructions following some sort of fixed hierarchy. This results in poor resource management and hence inefficiency. Since Disasters themselves are unstructured in scope and hence can't be managed centrally, there is a need for a user centric decentralised hierarchy independent approach wherein even the end user is empowered accordingly for quick and effective results. This working paper addresses the novel approach by underlining the need for a decentralised Information Network whose main objective is to match the available resources at any time with the needs, at the right time and to the right people. Our network uses concepts of multi mobile agents, mobile/AdHoc networking, real time operations, etc. The paper also presents a descriptive implementation setup of the network with the benefits accruing like efficient & effective resource management, real time networking, user centric and enabler decentralised operations, etc. Given the canvass and time-critical aspects of disasters, by this approach the level of success could be exponentially increased leading to an efficient, real time, and effective Disaster Management.

1 Introduction

A lot of research has been done on the traditional approach regarding technology viz., Management of Technology (MOT), Mobile Governance (mGov) [1], etc towards a new transversal and comprehensive vision of Technological Management [2]. There exists a set of active links between technology and the elements of management systems [3] and hence one can deduce that technology is impacted by and has an impact on all those functions, thereby underlining the importance of effective management of technology. One of the most important techno-management initiatives of the decade, Electronic Governance (eGov), has its inherent advantages and offers a new way forward helping connect citizens to the government [4]. However, one can argue about its success given that failing ratio is more than 60% [5, 6] and comparing with Baltius's ideal propositions [7]. Herein came our concept of 'Mobile Governance' (mGov) [1] facilitating the enhanced technologies incorporating new management propositions including inherent aspects like effective real-time information sharing, transparency, security, implementation through wireless/mobile/AdHoc/Distributed networking schemas. The present paper presents an application of mGov by taking on the area of Disaster Management that has a high impact on general populace and economy incorporating Multi Mobile Agent Approach (MMAA), Networking, Wireless Topologies, etc. Mobile communications might be concluded to have a 'Physical Level' that signifies that at least one of the communication partner is mobile, and a 'Social Level' which purports to forcing a partner to quickly switch (urgency, priority, etc) between social contexts [8, 9, 10]. It is this paradox of capturing and catering to the populace correctly that forms both a challenge as also an aspiration in our context.

2 Disaster Management

In 2002 alone, as per the latest report [11], a total of as high a number as 608 million people were reported affected worldwide by disasters with the total amount of estimated damage inflicted by disasters during 2001 as high as US$ 24 billion. Even after so much preparations, when comparing the decades 1983-1992 and 1993-2002, the number of people reported affected have risen by 54 per cent over the same period worldwide underlining the importance of the topic. Literally, the term "disaster management" (DM) encompasses the complete realm of disaster-related activities and can be defined [12] as "*...a set of actions and processes designed to lessen disastrous effects either before, during and after a disaster*." In our opinion, the critical success factor (CSF) for effective DM is that the level of approach should be a Grass-Root one rather than the typical haphazard/unstructured one that generally exists. We have incorporated this very approach in our DDMIN design, and have found out that the level of success could be exponentially increased this way. Our DMIN deals with the situations that occur prior to, during, and after the disaster and is facilitated with the electronic/IT/Mobile/Wireless components for effective and real-time solutions.

3 Strategic Frameworks

In this section we present relevant frameworks and our own model strategic framework:
Drabek Model: Drabek [13] proposed an approach through which it is possible to resolve disaster communications into four distinct levels of complexity that range from the individual to larger social and organizational system.
Thomas Model: Thomas [14] presented a categorical framework for disaster communications based on information flows, rather than functions or roles, and adopted a four-fold typology to examine technology issues and general communication problems:

- **Intra-organizational (Intra Org):** Communication within organizations
- **Inter-organizational (Inter Org):** Communication between organizations

- **Organizations-to-public (O to P):** Communication from organizations to the public
- **Public-to-organizations (P to O):** Communication from public to organizations

<u>Proposed Strategic Model</u>: Our strategic framework (refer Fig. 1) builds upon the Dedrick and Kraemer's [15] theoretical framework of an IT-led development and incorporates the distinct levels of communications complexity and Thomas's proposition of a concrete categorical framework for information flows. Our techno-management approach encompasses industrial policy, industry structure and environmental factors to showcase the relationship between IT and economic payoffs.

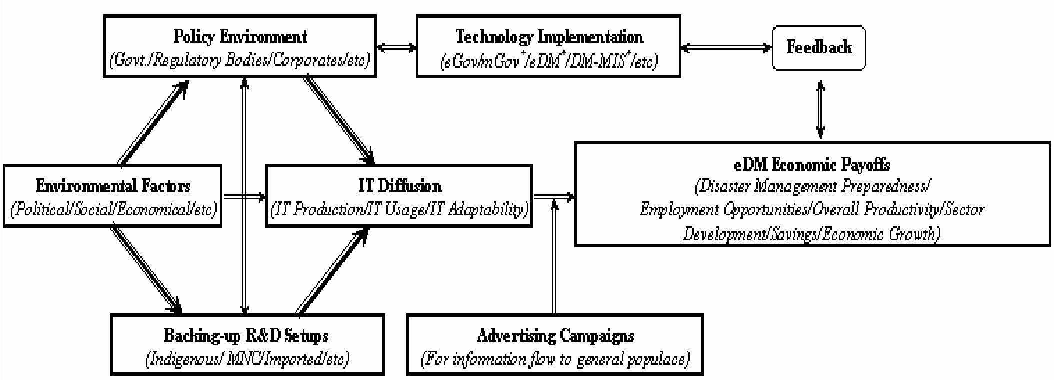

Fig. 1. Our Proposed Directional DM Strategic Framework

This model also takes into account the affects of IT in a heterogeneous atmosphere as compared to the homogeneous setups, viz., companies, firms, organizations, etc where the technology adaptability quotient, literacy levels etc are more or less static as against the former.

4 Decentralised DM Information Network (DDMIN)

Our research findings are reproduced below in a systematic manner:

For the purpose of modeling the structure, we had to research upon the existing hierarchy setups and found out that these are reflected similarly across the developing countries. The hierarchy structure of West Bengal state in India forms the backdrop for our prototyping purposes which consist of the following levels: District Level, Sub-Divisional Level, Block Level, Gram Panchayat Level and Booth/Volunteer Level.

The information flow would have the following four sets of headers:

(a)	To feed Information - UPDT	(c)	Instruct for info – INSTRCT
(b)	To see Information – CHCK	(d)	To seek instructions - SEEK

We hereby propose the concept of 'Thematic Entities (T-E)' rather than the established entities to develop our model. Against our research and starting from the grass root level, the structure could be divided in the set of eight T-Es as follows:

1. Water/Sanitation (WaTSaN)
2. Health (HLTH)
3. Food (FD)
4. Rescue/Shelter (RSCUE)
5. Emergency Materials (EM)
6. Infrastructure (INFRA)
7. Warnings (WRNG)
8. Volunteer Pool (VP)

DDMIN has four distinct zones of working: Normal Stage [N], Pre-Disaster Stage [P], Disaster Stage [D] and the Post Disaster Stage [PO]. Each stage has 4-5 key information points that have been researched upon through country analysis and the relevant terrain/situations. The number of Stage Information Points depends upon the type of disaster, degree of disaster and the locality.

Table 1. Information Interconnectivity Mapping

Sl. No.	Thematic Entity	Departments	Centers	Levels
1	WaTSaN	Health	▪ Primary Health Centre ▪ Sub Centre	• *Block & Panchayat* • *Panchayat*
		Public Health Engineering (PHE)	▪ PHE Deptt Centre	• *Block*
		Non Govt. Org. (NGO)	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
2	HLTH	Animal	▪ Veterinary Hospital ▪ Veterinary Centre	• *Block* • *Gram Panchayat*
		Human	▪ Primary Health Centre ▪ Sub Centre	• *Block & Panchayat* • *Panchayat*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
3	FD	Animal Resource	▪ Block Office ▪ Pranibandhu Office	• *Block* • *Gram Panchayat*
		Food Corporation	▪ FCI Office	• *Sub Divisional*
		Block Relief	▪ District Office ▪ Block Relief Office	• *District* • *Block*
		Panchayat Structure	▪ Panchayat Office	• *Gram Panchayat*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
4	RCUE/SHTR	Civil Defense	▪ CD Offices	• *District & Block*
		Block Relief	▪ District Office ▪ Block Relief Office	• *District* • *Block*
		Police Deptt	▪ Police Station	• *Block*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
5	EM	Block Deptt	▪ Block Office	• *Block*
		Panchayat Structure	▪ Panchayat Office	• *Gram Panchayat*
		Agriculture Deptt.	▪ Agriculture Office	• *Block & Gram Panchayat*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
6	INFRA	Administration	▪ Block Relief Office	• *Sub Division*
		Telecom	▪ Central Office	• *Central Govt*
		Police Deptt	▪ Police Station	• *Block*
7	WRNG	Irrigation Deptt	▪ Block Office	• *Block*
		Police Deptt	▪ Police Station	• *Block*
		Public Works Deptt	▪ PWD Office	• *Block*
		State Electricity Board	▪ SEB office	• *Block*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*
8	VPR	VPR Office	▪ Nodal Offices	• *Block* • *Gram Sansad* • *Gram Panchayat*
		NGO	▪ NGO Units	• *Block /Gram Sansad/ Gram Panchayat*

The entire information set could be depicted as [N P D PO] and the entire probable information points, for design purposes, could be calculated as follows:

$$I_p = E_n * T_e * Z_i * C_n \quad \text{……………………… (1)}$$

*Total Information points = [(Number of entities) * (Sub Themes of each entity) * (Number of zones) * (Critical information sets of each zone)]*

The figures (Fig 2 & 3) below showcase the concept.

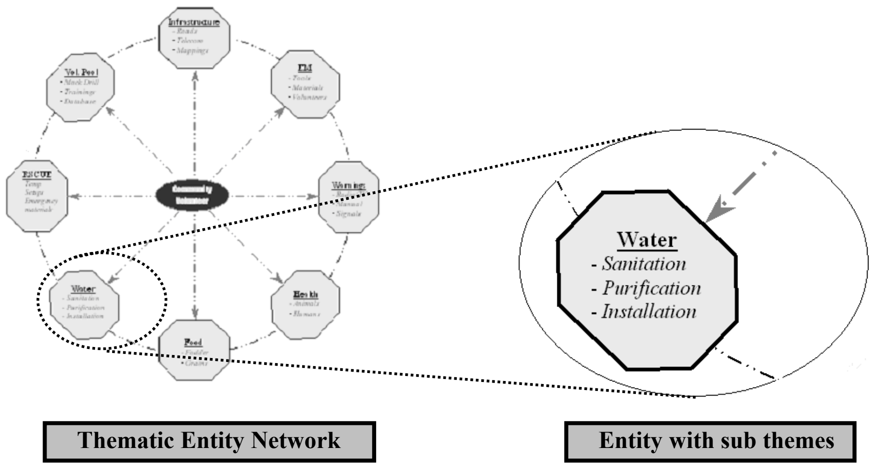

Fig. 2. Thematic Entity and its break-up

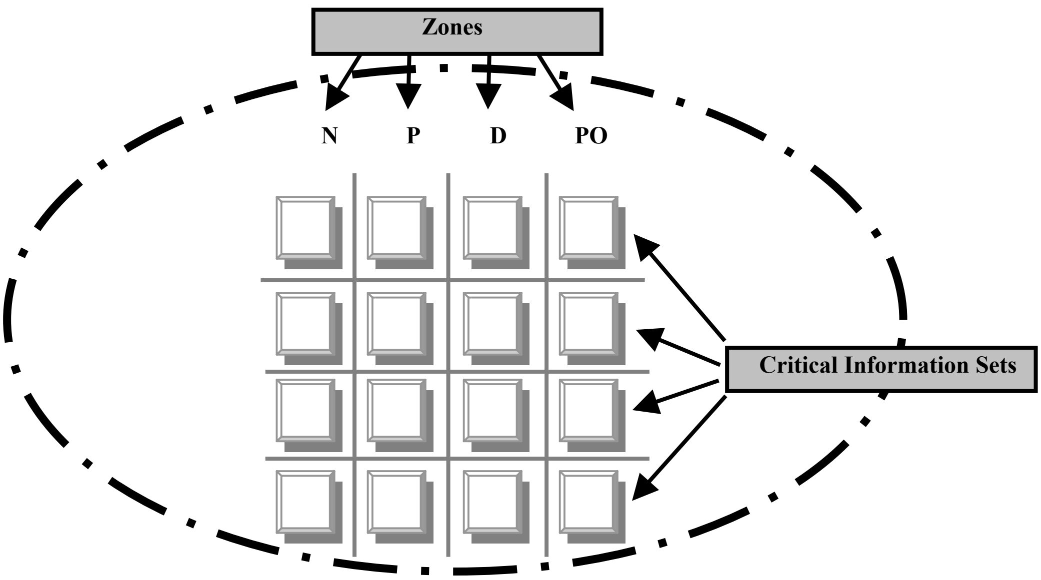

Fig. 3. DDMIN internal structure

Since the number is dependent of several factors like, type of disaster, geographic situations, environmental atmosphere, technology spread, etc, it is indeed a huge research problem whose address promises to contribute to the immense DM proportions worldwide.

A depictive self-explanatory implementation set up is as shown in Fig 4 below for quick reference.

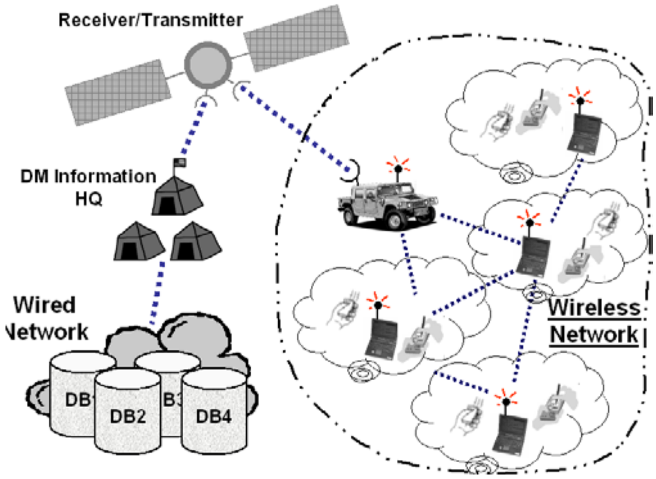

Fig. 4. Depictive Implementation setup

The proposed DDMIN utilizes the concept of Mobile Multi-Agent Systems. Broadly speaking, a mobile agent is an executing program that can migrate during the execution from machine to machine in a heterogeneous network atmosphere [16]. Mobile agents are especially attractive in a dynamic network environment involving partially connected computing elements [17]. Mobile agents could be effectively used for multifarious purposes ranging from adaptive routing [18], distributing topology information [19], offline messages transfer [20] and distributed information management [21]. One of the most important factors in our mobile agents' aided network is to collect all topology-related information from each node in ad hoc wireless network and distribute them periodically (as updates) to other nodes through mobile agents [22]. Once topology has been mapped the other two relevant aspects remain as Information retrieval and Information dissemination taking in the concepts of link stability, information aging, etc.

A centralized management is characterized by restricting important decisions to one or a few nodes on a given sub network wherein these special nodes become performance and administrative bottlenecks in a dynamic system [23]. A decentralized and fully peer-to-peer architecture like ours, on the other hand, offers potential advantages in scalability as also the scope. There is a growing interest in using mobile agents as part of the solution to implement more flexible and decentralized network architecture [24, 25].

Please refer to Fig 5 for an example query on health inventory status.

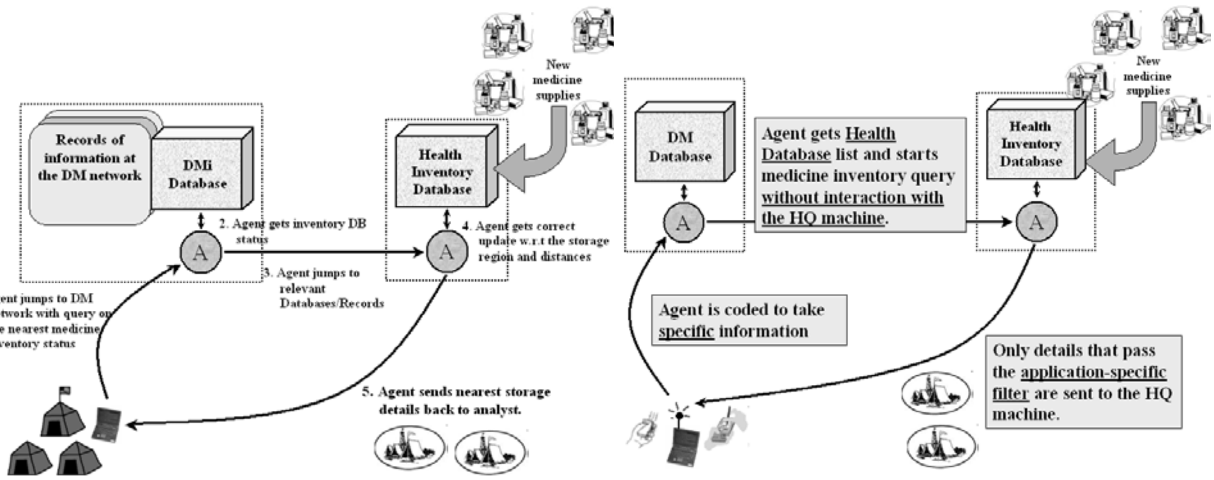

Fig. 5. Typical agent query system and an internal view of Agent-based query

DDMIN uses Flags/Emails/SMS for both off-line messaging and on-line instant messaging schemes [19].

5 Conclusions

In this working paper we extend the concept of mGov by taking an application in the context of Disaster Management. While we have incorporated the mobile technologies in the mGov and DMIN set-ups, the prime issues of interest still remains the Service Delivery, democracy, governance and law enforcement [26]. Application development is another aspect that has an immense scope for research. The applications as also the end product should be so developed so as to take into account the literacy levels, technology adaptability, ease of usage, effective GUI techniques, etc. Standards of technology and the effective bandwidth allocation are considered to be two of the most important aspects of wireless applications and their full potential [27] as also the security and authorisation policy matters.

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