Interoperability for Extreme Events Research Group

THE UNIVERSITY OF SYDNEY
Business School

Metamodelling for Disaster Management

The Disaster Management (DM) involves collaborative decision making activities often characterised by a high level of complexity involving different sources of knowledge distributed across time, space and people. In Australia, various DM activities and knowledge units required throughout the DM processes are organised according to the sequence of four phases: *Prevention, Preparedness, Response and Recovery* or often known as the PPRR model.

With all its prominence, PPRR has been criticised for not conceptualising the process of disaster management holistically, rather it does it sequentially (Rogers 2011). This has been explained as a relic feature of PPRR associated with it predating the modern view of aiming to have *risk management* permeate all activities in the process (Crondstedt 2002). A linear and a sequential description of events is inherently limited as it does not allow participants to engage beyond the tip of the timeline. In software processes this sequential modelling has been abandoned many years ago to mitigate the risk of introducing software errors. It is well accepted that software practitioners typically engage in iterative thinking and problem solving, moving up and down multiple abstraction layers. Applying this same paradigm and insights to representing disaster management processes, we developed a 3-D knowledge representation to enable layering of abstractions and abandoning timeline, in favor of free flow accessing of any point. We call this representation, a DM Metamodel (DMM) (Othman and Beydoun 2014).

DMM addresses many of the issues that surrounds PPRR usage. As practitioners are engaged in responding to a disaster, their actions are event driven however their reflections and motivation may be policy driven or even constrained within the structure of their organisation. In other words, knowledge generated during the events pertain not only to the event, but also to the policy development and perhaps reflections on scope for restructuring. Enabling the representation of this abstract knowledge is paramount to enable continuous process improvement. PPRR is limited by capturing only one perspective at a time and furthermore it assumes sequencing of the activities of planning, preparedness, response, and recovery (PPRR).

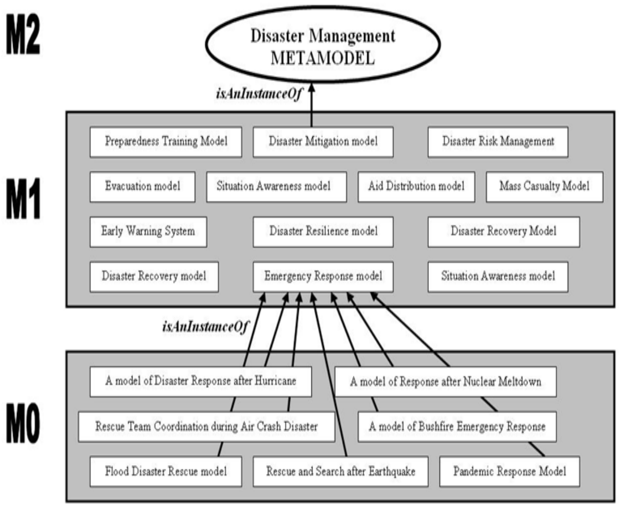
M2
Disaster Management METAMODEL
isAnInstanceOf
M1
Preparedness Training Model
Disaster Mitigation model
Disaster Risk Management
Evacuation model
Situation Awareness model
Aid Distribution model
Mass Casualty Model
Early Warning System
Disaster Resilience model
Disaster Recovery Model
Disaster Recovery model
Emergency Response model
Situation Awareness model
isAnInstanceOf
M0
A model of Disaster Response after Hurricane
A model of Response after Nuclear Meltdown
Rescue Team Coordination during Air Crash Disaster
A model of Bushfire Emergency Response
Flood Disaster Rescue model
Rescue and Search after Earthquake
Pandemic Response Model

Figure 1: A 3-layered representation of DM. M0 = Event, M1 = Policy and practice and M2 = Structure.

DMM synthesis with metamodelling

In software engineering, a metamodel aims to create interoperable, reusable, portable software activities and components. A *metamodelling* process generates the metamodel and generally aims to create a collection of *classes* to describe domain concepts to represent domain entities, actions or states (Othman and Beydoun 2013). This collection of concept is the *metamodel*. A metamodel also contains the specification of modeling environment and defines the syntax and the semantics of the domain. It can be viewed from three different perspectives: i) as a set of building blocks and rules used to build new models, ii) as a model of a domain of interest and iii) as an instance of another model. In our context, a metamodel is a fundamental building block that makes statements about the possible structure of DM models [10]. Replacing PPRR with a rigorous metamodel will achieve the following: generalizing practices through collecting domain concepts, partitioning DM problems into sub-problems easier to tackle, and provide a well understood layered representation of knowledge. This representation will enable accessing/representing/engaging with knowledge at all levels of abstraction required (event, policy and structure) as proposed in Figure 2 below.

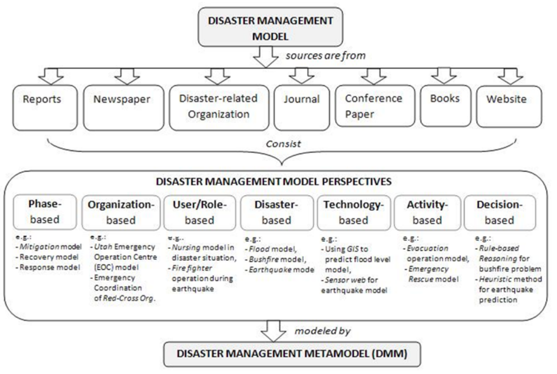
DISASTER MANAGEMENT MODEL
sources are from
Reports
Newspaper
Disaster-related Organization
Journal
Conference Paper
Books
Website
Consist
DISASTER MANAGEMENT MODEL PERSPECTIVES
Phase-based
e.g.: - Mitigation model - Recovery model - Response model
Organization-based
e.g.: - Utah Emergency Operation Centre (EOC) model - Emergency Coordination of Red-Cross Org.
User/Role-based
e.g.: - Nursing model in disaster situation, - Fire fighter operation during earthquake
Disaster-based
e.g.: - Flood model, - Bushfire model, - Earthquake mode
Technology-based
e.g.: - Using GIS to predict flood level model, - Sensor web for earthquake model
Activity-based
e.g.: - Evacuation operation model, - Emergency Rescue model
Decision-based
e.g.: - Rule-based Reasoning for bushfire problem - Heuristic method for earthquake prediction
modeled by
DISASTER MANAGEMENT METAMODEL (DMM)

Figure 2: DMM Metamodelling Process

We developed DMM using publicly available knowledge about DM processes and practices from nearly 89 international sources. We validated its effectiveness in Othman and Beydoun (2014) following the metamodelling process described in Figure 2.

Issues for practitioners

The harder task is converting current domain descriptions to DMM. In other words, the challenge is how to convert end user models to concepts and notation from DMM. We see Agent Oriented (AO) analysis as thus far, the most promising approach towards this. A current PhD project is tackling this question and validating this hypothesis. Agent oriented models indeed seem to lend themselves to represent organizational know-how and DM processes. Agent modeling emphasizes the constructs of *roles, agents* and *organizations* to represent systems behaviors. Analysis of various flood disaster plans used across Australia reveals similar emphasis. Much know-how and processes are expressed in similar terms. With appropriate supporting tools, this organizational knowledge can be deposited and shared using a DMM-based system. To validate this approach, a knowledge system was developed. Current efforts are focusing on creating an agent-based process to convert flood management knowledge and transfer it into the system. The DMM-conversion process is being validated with Displans from Wagga Wagga courtesy of a UOW Linkage Grant with SES in 2014.

References

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This information sheet has been prepared for the IEERG by
Ghassan Beydoun (University of Wollongong)
For more information
Interoperability for Extreme Events Research Group
sydney.edu.au/business/research/ieerg

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