Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 124 (2017) 116–124

Procedia Computer Science

www.elsevier.com/locate/procedia

4th Information Systems International Conference 2017, ISICO 2017, 6-8 November 2017, Bali, Indonesia

Disaster Knowledge Management Analysis Framework Utilizing Agent-Based Models: Design Science Research Approach

Dedi Iskandar Inan[a,b,*], Ghassan Beydoun[b]

[a]*Department of Informatics Engineering, Engineering Faculty, Universitas Papua, Indonesia*
[b]*School of SML, Faculty of Engineering and Information Technology, University of Technology Sydney, Australia*

Abstract

Disaster Management (DM) knowledge has long been acknowledged as playing a significant role in reducing the impact caused by disasters. It helps people at the decision-making level to produce contextual decisions, as they are produced from the interaction of the involved social entities and their experiences and those who are on the ground to appropriately react towards the disaster. While it is seen as critical the DM activities, its adoption is still challenging due to its complex structure and availability. This paper employs the Design Science Research (DSR) methodology in Information System (IS) research to develop and validate a knowledge transfer analysis framework to unify access to semi-structured DISPLANs (Disaster Management Plans) through a unified repository. In the development, Agent-Based Models (ABMs) are used to code the DISPLANs to enable their transfer into a repository. The Meta Object Facility (MOF) Metamodeling Framework is then used to create a repository that is ready for storing the content of ABMs. This developed framework is then validated using a real case study of the flood DISPLAN of the State Emergency Service (SES) the State of Victoria, Australia. At the end, this paper contributes to: (1) a validated knowledge transfer analysis framework supporting DM resilience endeavors; (2) demonstrate the DSR methodology as a frame for IS research.

Peer-review under responsibility of the scientific committee of the 4th Information Systems International Conference 2017.

Keywords: Disaster Management; Design Science Research; Agent-Based Model; Knowledge Management; Metamodeling

* Corresponding author. Tel.: +6281344481898
E-mail address: d.inan@unipa.ac.id; dedi.i.inan@student.uts.edu.au

1877-0509
Peer-review under responsibility of the scientific committee of the 4th Information Systems International Conference 2017
10.1016/j.procs.2017.12.137

1. Introduction

Currently, the agency leading the program to combat the disaster assumes the role of organizing and eliciting the knowledge, and ultimately structuring it in a shareable and reusable format. The knowledge is produced as Disaster Management Plans (DISPLANs). However, accessing the knowledge specified in a semi-structured natural language format is very challenging. The written knowledge tends to be structured in a business specification format which, in fact, is seen as subjective by the stakeholders. Much analysis may be required to enable development of useful and actionable insights. In this paper, we view the challenge of DM as one of harnessing and sharing knowledge between stakeholders who are involved in the timely and effective reduction of the impact of a disaster. The first step towards this is to revisit the codification of DM knowledge document sources to facilitate the reuse and sharing of the knowledge they contain. But analyzing the written knowledge in a complex domain, such as DM, is not only difficult but also time-consuming [1]. With all its prominence in DM activity, Prevention, Preparedness, Response and Recovery (PPRR) does not actually conceptualize the process of DM knowledge holistically, rather it does it sequentially [2]. This feature of PPRR is completely inconsistent with the modern view of aiming to have risk management permeate all DM activities.

It is well accepted that software practitioners typically engage in iterative thinking and problem-solving, moving up and down multiple abstraction layers. Linear and sequential descriptions of events are inherently limited. Participants are hindered from engaging beyond the limit of the event timeline. In order to mitigate the risk of introducing errors, sequential modelling was abandoned in the software development many years ago [3]. Applying this same paradigm and insights to representing disaster management processes, a multi-layered metamodeling approach which follows the Meta Object Facility (MOF) approach [4] is proposed. As a first knowledge analysis step to enable this, the paper proposes an approach based on Agent-Oriented Analysis (AOA) to appropriately codify DM knowledge.

Drawing from the emerging DSR methodology in IS [5], this paper contributes to this field by introducing a knowledge transfer analysis framework. This is a framework in which the DM knowledge is analyzed prior to transfer. The aim is that the complex characteristic of the knowledge can be disentangled and subsequently transferred into a representative repository, facilitating sharing and reusing activities. In addition, this paper demonstrates that the knowledge deposited in the repository can be the foundation of a comprehensive and holistic decision making mechanism in disaster events. This due to the fact that Agent-Based Models (ABMs) are capable to parse the complex characteristics in the DM that are inherently existed hampering the affective and efficient activity. The DSR frames the research activities to rigorously develop and validate the framework through proof of concept, proof of use and proof of value [6]. To the end, the developed and validated framework facilitate a better knowledge representation in the repository that can contribute to the DM resilience endeavors.

The essay proceeds as follows: The following section provides related works from the extant literature of the study. Section 3 discusses the methodology underpins this research. Section 4 illustrates the development of the artefact. Section 5 elaborates the evaluation strategy of the developed artefact. Section 6 presents the discussion and this research is concluded by Section 7.

2. Related works

The DM knowledge has four characteristics in common with ABMs: a) Situatedness in an environment [7]. As disasters are dynamic, unpredictable and uncertain, the environment changes rapidly which leads to the second characteristic. b) Time sensitivity [8]; in a disaster, every activity has to deal with deadlines, otherwise the consequences might lead to casualties, or even fatalities. c) Non-deterministic [9]. Disasters often throw up unexpected eventualities. This factor means the level of unpredictability is very high. d) Presence of autonomous entities [10]. This means that in a DM activity, individuals/agencies/organizations are coming from different backgrounds, knowledge, abilities, structure, mandate, with no common perception and so on. The agent-based modelling approach enables analysis of complex systems, in particular socio-technical systems.

Various researches have been undertaken in an attempt to structure the DM knowledge to be better understood [11-13]. Of all these, one of the most notable is described by Othman et al. [11]. In their work, they do not only prescribe how the knowledge is structured addressing the knowledge layers from conceptual to planning to the real