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Advanced Information System Approach to Design of Emergency Response on Natural Disaster

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***Abstract* – A natural disaster is a sudden event that causes widespread destruction, lots of collateral damage or loss of life, brought about by forces other than the acts of human beings. A natural disaster might be caused by earthquakes, flooding, volcanic eruption, landslide, hurricanes etc. In order to be classified as a disaster it will have profound environmental effect and/or human loss and frequently incurs financial loss.Natural disasters have highlighted the need for disaster awareness, planning, and management. Government established the usefulness of Web sites in dealing with natural disasters. However, little is known about the necessary things and structures of Web-based information systems for natural disaster management. In this paper, we focus on developing an ontology structure of elements for Web-based disaster management systems. Web elements are identified, following a grounded theory approach, from an catalogue of Web pages drawn from disaster managing Web-sites. Selected semi structured Data representation approaches are used to systematize the resulting ontology structure, which consists of 2094 Web elements.**

***Keywords* – Disaster Management, Grounded Theory, Ontology Design, Qualitative Analysis, Schema Integration, Web Design.**

I. Introduction

From the last 2 years to till, the largest disasters we have seen are Uttarakashi flash flood Torrential rains in August led to flash floods and Very Severe Cyclonic Storm Phailin was a tropical cyclone that affected Thailand, Myanmar, Nepal and the Indian states of Andaman and Nicobar Islands, Odisha, Andhra Pradesh, Jharkhand and West Bengal The use of the Web in disaster recovery efforts demonstrated the usefulness of Web sites in dealing with a disaster. The ubiquity and asynchrony of the Internet make it a natural platform for information exchange and communication for managing mass crises.

Although there are many disaster-related Web sites, little is known about the necessary contents and structures of such sites. This paper presents a first attempt in developing an ontology structure of elements for such Web sites. We strive to answer the following research questions.

1) What data demonstration approaches are suitable for developing an ontology structure of Web elements in Web-based natural disaster management systems (WB-NDMS)?

2) What are the necessary Web elements and their ontology structure for WB-NDMS?

3) How should one develop such an ontology structure based on available sample data?

4) How can such an ontology structure be distributed online for simple navigation?

An accessible and comprehensive ontology structure developed in this research, called Web- based ontology structure (WB-OS), can potentially assist organizations, managers, and individuals who are involved in disaster management in their WB-NDMS development and evaluation. First, it provides a useful resource to those who are involved in developing WBNDMS.WB-OS covers all phases of natural disaster management and allows easy navigation of the ontology structure at different levels of detail.

II. Background

Across the world, disasters happen frequently. There are various types of disasters, including natural disaster, technological disaster, pandemic disaster [7], and mass violence, where each of which has certain level and type of impacts [8]. Although the impacts of disasters have been extensively investigated, there has been inadequate research on the design of disaster management systems. Furthermore, little attention has been paid to Web-based disaster management and its contributions to the well-being of affected individuals and organizations. More generally, existing research on emergency response information systems is still scant [9], [10].

In this paper, we focus on natural disasters and, specifically, on issues related to the design of Web-based information systems for managing various phases of natural disasters. A natural disaster may be a hurricane, tornado, typhoon, flood, fire, or earthquake. Generally, "a natural disaster occurs when an extreme geological, meteorological, or hydrological event exceeds the ability of a community to cope with that event"[11, p. 176].

In this crisis period, Pearson and Mitroff[12] suggested that there are five phases in disaster management:signal detection, preparation/prevention, containment/damage limitation, recovery, and learning. Signal detection is stand-alone phase in organizational disasters. For natural disasters, however, signal detection and preparation typically take place in the same phase. Osn the other hand, there is a "general preparation" phase, which is not tied to

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a particular disaster occurrence but is related to information and public education. Similarly, Mileti [13] proposed a model of disaster management with four phases: mitigation, preparedness, response, and recovery. Developing the web-based applications is difficult in various phases of natural disasters.

III. RESEARCH METHODOLOGY

Following a grounded-theory approach, we identify the Web elements from the following Web sites that are related to natural disaster management. To handle the complexity of these elements, we develop an ontology [16] with a hierarchical structure using a proposed incremental schema integration (ISI)method and employ selected semi structured data representation approaches to code the ontology structure. An ontology is “an explicit specification of a conceptualization” [17, p. 199]. The main purpose of ontologies is to facilitate knowledge sharing and promote reuse [17], [18]. In an ontology, we define the terms of a domain and identify the relationships among them, thereby formalizing domain knowledge. In this paper, we group and define the Web elements in the WB- NDMS and identify the relationships among them, hence creating an ontology structure for the Web elements.

A. Grounded-Theory Approach

To identify the Web elements, we follow the grounded theory approach which advocates an iterative, qualitative, and inductive process [20]. The grounded theory was originally developed by Glaser and Strauss in 1967 [19]. Later, Strauss and Corbin [21] proposed a more structured process with three types of coding: open, axial, and selective. Starting with a Collection of qualitative/textual data, open coding involves an inductive and iterative process of constant comparison and categorization of data, leading to the emergence of unitary abstract concepts. These concepts are further categorized, and their relationships are established at the axial stage of the coding process, again using constant comparison and categorization. The relationships normally have a hierarchical structure. The selective coding stage involves further abstraction and the development of an emergent theory or the conceptualization of a general structure from the data.

With the following open coding, we can compare and contrast data elements leading to conceptual Web elements and their categories. The axial coding process structures the categories in hierarchies of relationships. New data elements are introduced iteratively, the analysis is repeated, and the results are modified. The process continues until all of the available data have been consumed or the to construct the ontology structure for web-based applications we use five categories that correspond to five phases of natural disaster. Within these five main categories, subcategories surface through a constant comparison of Web elements found in various natural disaster management Web sites. We embed the grounded-theory approach within the proposed method for developing the ontology structure (as discussed in the following).

Table I: Basic Summary Statistics about the Collected Web Sites

Type	Number of Sites	Average Number of Pages Per Site
State Sites	50	67
City and County Sites	37	35
Other Governmental Sites	8	130
Non-profit Organization Sites	3	97
Commercial Company Sites	2	29

Select eXtensible Markup Language (XML) [24], XML Schema [25], and Document Object Model (DOM) [26] as the specific modeling approaches. We use XML to represent semi structured data models. A semi structured data model is used to capture the structure of a document instance [27]. XML is one of the most popular data models for semistructured data on the Web today [28].

We use XML schema to represent data schemas. A data schema is an abstraction of data models, and it contains constraints, types, and relationships of the data elements. For the semi structured data, the structure is often not fully known in advance and is created after the data become available [29].

B. Proposed ISI Method

Following the axial and selective coding in the grounded theory, we apply a schema integration approach in integrating the semistructured data schemas derived based on different disaster management Web sites. Schema integration is “the activity of integrating the schemas of existing or proposed databases into a global unified schema” [34].

Schema Matching: Naming conflicts and naming matching are checked, marked, and maintained in this phase. The first step of schema matching is to find the corresponding elements from two schemas: the current global schema (Gj−1 prior to round j) and the local schema (Lj) under investigation. Initially, the global schema G0 has the root “Natural Disaster Management” and one level with five Web-element categories that correspond to the five phases of natural disaster management. In a subsequent round (j), we match the Web elements in the local schema (Lj) with those in the global schema (Gj−1) using a nested breadth-first search. We consider the Web elements in Lj in a breadth-first manner. For each Web element (m) in Lj , we search for a matching Web element in Gj−1, also in a breadth- first manner. If the parent or an ancestor ofmhas already been matched to aWeb element n in Gj−1, the search for a Web element in Gj−1 matching m is restricted to the subtree

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rooted at n. Starting from the root of each schema tree, we mark the matching Web elements.According to the schema matching literature [37], [38], while several semiautomatic matching techniques have been proposed, human intervention is still necessary. We carry out the enumeration of the Web elements manually in this paper.

C. Ontology Structure Development

Ontology development is labour intensive and time consuming. There are several techniques for learning ontological. However, fully automating the ontology development process still remains infeasible, and most learning techniques require some existing top-level ontology or seed concepts [40]. Considering the novelty of our ontology structure development process (this is a first attempt in developing an ontology structure of elements for WB-NDMS) and the lack of an existing natural disaster management dictionary,we choose to adopt a manual procedure and follow a rigorous grounded-theory approach, trading efficiency for higher quality.

VI. Conclusion and Future Research

By understanding the necessity of Web elements and their ontology structure it has critical implications in the development of an effective applications. The first research question was on the choice of appropriate approaches for managing the large and complex structure of Web elements. The second research question was related to the identification of Web elements and ontology structure for WB-NDMS. By combining the grounded-theory approach and the selected data representation approaches, we have proposed a procedure for this purpose.

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