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ONTOLOGY STRUCTURE OF ELEMENTS FOR WEB-BASED NATURAL DISASTER PREPAREDNESS SYSTEMS

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Abstract

Recent natural disasters have brought forth the need for disaster preparedness, planning, and management. Hurricane Katrina demonstrated the usefulness of websites in dealing with a natural disaster. However, little is known about the necessary contents and structures of web-based information management for natural disaster preparation. In this paper, we focus on developing the ontology structure of elements for web-based disaster preparedness systems. We provide a comprehensive review of the existing semi-structured data representation technologies and select the appropriate set for developing and representing the ontology structure. Web elements are identified based on the grounded theory approach using an inventory of 100 non-profit disaster websites and their numerous webpages. The selected technologies are used to organize the ontology structure and the results are coded into a web-based system tool (WB-OS) that makes the ontology structure accessible on the web. Contributions to research and practice are discussed.

Keywords: Disaster preparedness, natural disaster, web-based information systems, semi-structured data, grounded theory

Motivation and Research Questions

In the 2005 hurricane season, the largest three hurricanes, Katrina, Rita and Wilma, impacted over millions of lives (American Red Cross 2005b). Katrina devastated nearly 90,000 square miles. Rita struck within a month, damaging and destroying more than 350,000 residences (American Red Cross 2005a). The use of the web in disaster recovery efforts demonstrated the usefulness of websites in dealing with a disaster. The Internet with its ubiquity and asynchrony is a natural platform for information exchange and communication for managing mass crisis. Although there are many disaster-related websites, little is known about the ontology of elements that should be used on such sites and their structure. This paper is the first in attempting to answer the following research questions:

- *What are the suitable data representation approaches for developing the ontology structure of web elements in web-based natural disaster preparedness systems (WB-NDPS)?*
- *What are the web elements and their ontology structure for WB-NDPS?*
- *Can the ontology structure of web elements for WB-NDPS be implemented online?*

The potential contribution of this research is to identify an accessible and comprehensive ontology structure for creating WB-NDPS to assist organizations, managers, and individuals, who are involved in disaster preparedness. This work also shows how the synthesis of ontology, grounded theory, and semi-structured data representation technologies could make it possible to identify and code the ontology structure of web elements for a complex and large domain. Furthermore, our work could be extended to develop and implement the ontology structure for all stages of web-based disaster management for different types of disasters.

Background

Disasters happen frequently across the world. There are different types of disasters, including natural disaster, technological disaster, or mass violence, each of which has different level and type of impacts (Norris 2005). Although impacts of disasters have been examined in the disaster management literature, they have seldom been examined from the information systems viewpoint. Furthermore, little attention has been paid to web-based disaster management and its contributions in well-beings of individuals and organizations. In this research, we focus on natural disasters and the issues related to the design of web-based information systems in managing various stages of such disasters from the perspectives of multiple stakeholders.

A natural disaster may be a hurricane, tornado, typhoon, flood, fire, or an 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 (Lindell and Prater 2003, p. 176)." In the context of organizational crisis, Pearson and Mitroff (1993) suggest that there are five phases in a disaster: signal detection, preparation/prevention, containment/damage limitation, recovery, and learning. However, signal detection is more important in organizational disaster. For natural disasters, signal detection and preparation should take place in the same phase. On the other hand, there is a "general preparation" phase, not related to any given occurrence of a disaster, but related to information and public education regarding general preparation for natural disasters. Therefore, we argue that the management of a natural disaster involves the following five stages. (1) The first stage involves general preparation for various natural disasters. The goal of this stage is to prepare and plan for future occurrences of disasters and educate stakeholders about the course of action in such circumstances. (2) In the second stage, a given disaster is predicted and specific plans should be put into place. (3) The third stage is when the disaster is in progress. The goal of this stage is to assist those in immediate danger and reduce and contain the damage. (4) Recovery begins immediately after a disaster, including a wide range of activities such as process restoration and individuals' health recovery. (5) Finally, the lessons learned from current disaster should be assimilated as a practice for the refinement of general preparation for the next round.

Web elements are critical in developing web-based systems to deal with various stages of natural disasters. Web elements are the features, components, and information used to create websites. In the context of e-commerce website, Song and Zahedi (2005) identified web elements by using a grounded theory approach and categorized them. These categories have been used to develop a theoretical foundation for the connection between web elements and beliefs (Song and Zahedi 2001; Song and Zahedi 2005). Web elements for WB-NDPS are numerous and are far more complex than those in e-commerce. Furthermore, there has been little attempt in conceptualizing these elements. Therefore, there is a gap in the knowledge about the nature, structure, and categories of web elements for developing WB-NDPS. Our study is the first to address this gap.

In this study, we identify web elements of NDPS using the grounded theory approach and data from an inventory of 100 websites. To handle the complexity of these elements, we develop the ontology of web elements in a hierarchical structure. Ontology, a term borrowed from philosophy, is "an explicit specification of a conceptualization (Gruber 1993, p. 199)". The main purpose of ontology is to share knowledge and promote reuse (Gruber 1993; Noy and McGuinness 2001). In ontology, we define terms and vocabulary of a domain and identify the relationship among them. In this study, we group and define web elements in WB-NDPS and identify the relationship among them, hence manually creating an ontology structure for the web elements.

In order to develop and implement the structure, we review the literature of semi-structured data modeling representation in order to select the technologies appropriate creating the ontology structure of WB-NDPS. We synthesize the grounded theory approach with the selected technologies to develop the ontology structure. We also use the selected technologies in coding the ontology structure and making it available as a web-based tool called Web-Based Ontology Structure (WB-OS). Our WB-OS tool could be navigated at different levels of details. It provides a useful resource for those who are involved in developing WB-NDPS. At present, WB-OS covers the structure for the first two phases of disaster management: general preparation and preparation for a given disaster. Our plan is to extend it to cover all phases of natural disasters and later extend it other types of disasters.

Review of Data Representations Models and Choice of Technologies

In identifying and structuring the ontology of web elements for NDPS, the complexity and volume of data could be overwhelming. Therefore, a careful review and choice of appropriate technologies is of critical importance. Several popular database design methodologies have been used for database management systems, including entity-relationship modeling in relational databases (Chen 1976), object-oriented database (Rumbaugh et al. 1991), or object-relational database (Stonebraker and Moore 1996). More recently, semi-structured data management has emerged in response to the following needs. First, data types with less rigid structures, such as web traffics, are on the rise. Second, issues related to data integration arise when data are combined from several heterogeneous sources (Abiteboul et al. 1997; Buneman 1997; Quass et al. 1995). The issue of data integration is of importance in our study since following the grounded theory approach, we need to constantly identify, compare and categorize new web elements as we investigate various websites and their numerous webpages. Furthermore, the data representation of web elements in WB-NDPS should be flexible and extendable. Hence, in the following discussion, we focus on reviewing semi-structured data representations, their strength and weaknesses, and finally on the choice of technologies for implementing the ontology structure.

Definition of Semi-structured Data

Semi-structured data, such as text and documents, often have variable structures, rapidly changing schema, or incomplete schema. Although there is no universal definition of semi-structured data, definitions from various research streams offer similar meanings (Table 1). Here, we refer semi-structured data as a type of data without a pre-defined structure. It can be represented in a textual or graphical format.

Table 1: Definitions of Semi-structured Data

Author	Definition
(Abiteboul 1997)	"Data is neither raw data, nor very strictly typed as in conventional database systems." (p. 2) "The structure is irregular… implicit… partial…" (p. 3)
(Abiteboul 2001)	"Semistructured data is data that presents some regularity (it is not an image or plain text) but perhaps not as much as some relational data or some ODMG data (the standard of object databases)." (p. 379)
(Buneman 1997)	"The underlying idea in semistructured data is the representation of data as some kind of graph-like or tree-like structure." (p. 118)
(Connolly and Begg 2005)	"Data that may be irregular or incomplete and have a structure that may change rapidly or unpredictably." (p. 1066)
(Fernández et al. 2000)	"Semistructured data is characterized as having few type constraints, a rapidly evolving schema, or missing schema and is typically modeled by a labeled, directed graph." (p. 39)
(Goldman and Widom 1997)	"Semistructured data may exhibit some structure, it is too varied, irregular, or mutable to easily map to a fixed schema." (p. 1)
(Ling et al. 2005)	"The less structured data, also known as semistructured data, is usually represented as a tree of elements, where the children are sub-elements of their parent element. Elements can in turn have attributes." (p. 2)
(Quass et al. 1995)	"Semistructured data has no absolute schema fixed in advanced and its structure may be irregular or incomplete" (p. 1)

Models and Schema for Semi-structured Data

In order to organize, model, and create the ontology structure of web elements, we need data modeling technology that has both text and graphical capabilities. Furthermore, a data schema technology is needed that has the same text and graphical capabilities. Semi-structured instances are stored in data models (or data instance models). Their structure can be described in data schema when the instances are available. For example, for a semistructured data describing books' information, data models represent instances of books with different number of authors. Data schema, on the other hand, describes the overall structure of these data models and includes only a single book element and a single author element. The schema should also represent the relationship between the book element and the author element. In our study, we start with "instances" of web elements with the goal of identifying the web elements and their relationship in a schema that represents the ontology structure.

Data modeling technologies for semi-structured data include eXtensible Markup Language, Object-Exchange Model, and Lore's XML Data Model. The data schema technologies for semistructured data include Document Type Definition, S3-Graph, DataGuides, and XML Schema. Document Object Mode is used for graphical representation of both data models and data schemas. In what follows, we briefly review these technologies and their capabilities in order to choose the data model and data schema that have the needed capabilities for developing and representing the ontology structure of web elements for WB-NDPS.

Data Models for Semi-Structured Data

Extensible Markup Language (XML). Extensible Markup Language (XML), a W3C (World Wide Web Consortium) recommendation, is a data model designed as a standard for data representation and data exchange on the Internet (Bray et al. 2006). It allows designers to create their own customized tags (elements) to represent their own document structure. The tags are not pre-defined such as the ones in Hyper Text Markup Language (HTML). It is also one of the most popular data model for semi-structured data on the web today (Win and Hla 2005). However, it is only a text-based data model.

Object-Exchange Model (OEM). The Object-Exchange Model (OEM), originally proposed by Papakonstantinou et al. (1995), is the de facto model for representing semi-structured data. It is a self-describing data model, which has been used for integration of heterogeneous information source in various systems such as TSIMMIS project at Stanford University (Garcia-Molina et al. 1997) and Strudel developed in AT&T Labs (Fernández et al. 2000). Because of the flexibility of its structure, OEM can be used for data exchange and integration without pre-defined object structure. TSIMMIS integrates heterogeneous information by using OEM as a lightweight object model to handle rich collection of data structures. In addition, Strudel is a data-intensive web design methodology, which models data on various web pages using OEM. It has both text and graphical capabilities.

The fundamental concept of OEM is that data is represented as a collection of objects, each of which can be atomic (such as string or integer value) or complex (containing sub-objects). Lore's data model (Abiteboul et al. 1997; McHugh et al. 1997) is an OEM variation with different graphical representation. In Lore's graph, nodes are used to represent objects and edges are used to represent label. Similarly, Strudel system (Fernández et al. 2000), a variation of the OEM data model, uses labeled, directed graph, similar to OEM, for its data modeling. As in OEM, this model consists of objects directly connected by labeled edge with attribute names.

Lore's XML Data Model. Lore's XML data model is an extension of original Lore's data model used to map XML documents in graphical form (Goldman et al. 1999). Since XML does not have visualization capability, Lore's XML extends it by adding the graphical capability to XML data model. An element in XML document is mapped into a tuple <id, value>. Here, id is a unique element identifier and value is either text or relationship to sub-elements (Goldman et al. 1999).

Data Schema for Semi-structured Data

Traditionally, schema is used to define the structure of a database and exists prior to collecting and storing data. For semi-structured data, since there is no pre-defined structure, its schema is created after data become available (Abiteboul 1997). Data schema may have textual or graphical capabilities. The technologies for data schema include: Document Type Definition, DataGuides, S3-Graph, and XML Schema. DOM also provides graphical capabilities for XML schema.

Document Type Definition (DTD). Document Type Definition (DTD) (Bray et al. 2006) describes the valid syntax of an XML document. It defines the elements names which is available in the document, describes how the elements are nested, and declares the type of each element.

S3-Graph. A Semi-Structured Schema Graph (S3-Graph) is a directed schema graph. Each node of the graph may be either an atomic data type, such as text, or a reference to a complex object type, such as location (Lee et al. 2001). The relationship between two nodes is labeled on the directed edge. S3-Graph is used to combine and integrate the graphs of data models in order to create the schema graph.

DataGuides. DataGuides is a graphical representation that summarizes the structure of a database (Goldman and Widom 1997; Goldman and Widom 1999). It was originally applied in the Lore semi-structured database system to ease query formulation and query optimization, since the system did not have an explicit schema (McHugh et al. 1997). DataGuides is a schema graph, which can be applied to most semi-structured data models, such as OEM, with nodes and edges. Similar to the extension of Lore's OEM to Lore's XML data model, DataGuides was extended to manage the structure of Lore's XML data model. DataGuides can also be built directly from a DTD (Goldman and Widom 1999).

XML Schema. XML Schema, a W3C (World Wide Web Consortium) recommendation, is an XML-based alternative to DTD, describing the structure of an XML document. By W3C's definition, XML Schema is a set of schema components which are "the generic term for the building blocks that comprise the abstract data model of the schema" (Thompson et al. 2004). Since XML Schemas are written in XML rather than other format such as DTD, they are more extensible for reuse. In addition, XML Schemas can also be manipulated by XML DOM. XML Schemas are written by XML Schema language called XML Schema Definition (XSD).

Document Object Model (DOM). Document Object Model (DOM), recommended by W3C (World Wide Web Consortium), provides an interface to let programs to "dynamically access and update the content, structure and style of documents" (http://www.w3.org/DOM/). The DOM visualizes an XML document as a hierarchical tree with object nodes, which include element, attribute, and text nodes (Kesselman et al. 2004). Element nodes correspond elements in XML document and attribute nodes correspond attributes in XML. Also, the contents are stored in text nodes. In addition, DOM can manipulate both XML and XML Schema. In a DOM graphical representation, elements are shown on nodes.

Selection of Suitable Technologies

Table 2 provides a summary of the capabilities of semi-structured data models and data-schema representations. While all technologies have support for identifying elements, not all have the capability to assign an attribute to the element. For the ontology structure of web elements, we need to have the attribute support since we should be able to identify the relative importance of various elements in the ontology structure, once the ontology is created.

To develop the ontology structure, we need to choose one of the data modeling techniques to describe web elements and choose one of the schema representations to capture the structure. Thus, any combination of techniques that allows the transformation from data instance representation to schema representation could work. Table 3 shows advantages and disadvantages for possible combination of techniques. As shown in Table 3, the combination of XML, XML Schema, and DOM provides the best advantages and has no disadvantage for our purpose. Therefore, this is the combination we use in creating and implementing the ontology structure for web elements.

Table 2: Comparison of Semi-structured Data Technologies

Extent of Support by the Technology	Data Model			Data Schema				
	XML	OEM	Lore's XML	DTD	S3-Graph	DataGuides	XML Schema	DOM*
Textual representation	✓	✓	✓	✓			✓	
Graphical representation		✓	✓		✓	✓		✓
Schema support				✓	✓	✓	✓	✓
Instance support	✓	✓	✓					✓
XML Support	✓		✓	✓		✓	✓	✓
Attribute support	✓			✓			✓	✓
Element support	✓	✓	✓	✓	✓	✓	✓	✓

* DOM could be used for graphical representation of the data model as well.

Table 3: Advantages and Disadvantages of Possible Combinations of Technologies

Semi-Structured Techniques	Advantage	Disadvantage
XML and XML Schema with DOM	• **W3C recommendation** • **All are in XML format** • **Support elements and attributes** • **Supports text and graph**	
XML and DTD with DOM	• W3C recommendation • Support elements and attributes • Supports text and graph	• DTD is stored in its format rather than in XML
OEM and S3-Graph	• Support graphical representation	• Not a standard • Offers less support (per Table 2)
OEM and DataGuides	• Both techniques support graphical representation	• Not a standard • Offers less support (per Table 2)
Lore's XML and DataGuides	• Both techniques support graphical representation	• Not a standard • Offers less support (per Table 2)
Lore's XML and XML Schema	• Both techniques support graphical representation	• Not a standard • Offers less support (per Table 2)

Research Methodology

To identify web elements, the constant comparison approach in the grounded theory is utilized. Grounded theory is "the discovery of theory from data" (Glaser and Strauss 1967, p. 1). It involves an iterative process between data collection and analysis through contrasting and comparing findings at each stage with those of the next. We deployed the grounded theory approach in an interpretive manner. To construct the ontology structure for WB-NDPS, we have two categories: general preparation and preparation for a given disaster. Categories within these two main categories have been surfaced through constant comparison of web elements in various websites.

Website Selection

In order to have a comprehensive ontology structure, we needed a large inventory of websites with a wide and varied coverage of natural disaster preparedness elements. A collection of 100 disaster preparedness or disaster management websites from various government agencies and non-profit organizations were identified. Various webpages of these websites included a vast array of web elements, which were compared and categorized as in the grounded theory.

Development of the Ontology Structure

Noy and McGuinness (2001) provide a seven-step guideline to design an ontology: (1) determine the domain and scope of the ontology, (2) consider reusing existing ontologies, (3) enumerate important terms in the ontology, (4) define the classes and the class hierarchy, (5) define the properties of classes--slots, (6) define the facets of the slots, and (7) create instances. The focus of the first four steps is to develop an ontology structure, while the last three implement the ontology with instances. Thus, the first four steps were used to develop the ontology structure for web elements.

There is no reported structure or ontology for web elements in WB-NDPS. Therefore, we had to enumerate important terms and categorize web elements from scratch. Based on the grounded theory, the following procedure was applied for identifying instances of web elements, categorizing them into web elements, and identifying the relationships among the web elements. The instance of web elements and their relationships were modeled using XML and DOM. The DOMs were compared and contrasted in order to allow for the XML schemas to emerge, which were visualized using DOM.

Step 1: Access the first website.
Step 2:
Step 2-1: Access a webpage of the site.
Step 2-2: Identify information on the page as instances of web elements and model them using XML and represent them in the graphical data model DOM. Add the XML and DOM to the inventory.
Step 2-3: Similar web elements are found in the inventory, compare and contrast them, and allow an XML Schema to emerge as the result of the comparison and use DOM to show the structure of the schema. Replace the two compared and contrasted XMLs with the emerged XML Schema and the corresponding DOM.
Step 2-4: Obtain another webpage of the site if any and repeat Step 2-2 to 2-3.
Step 3: Obtain the next website if there is any and repeat Step 2-1-2-4 until all elements in the websites are analyzed.

The Step 2-2 corresponds with stages of enumeration of terms and defining classes in ontology development. Furthermore, Step 2-2 accomplishes the categorization phase of the grounded theory. Step 2-3 corresponds with the development of class hierarchy in ontology development and accomplishes comparison and further categorization phase in the grounded theory. Step 2-4 is accomplishes the “constant” aspect of the comparison in the grounded theory, which requires continuation of process and building from additional data and evidence.

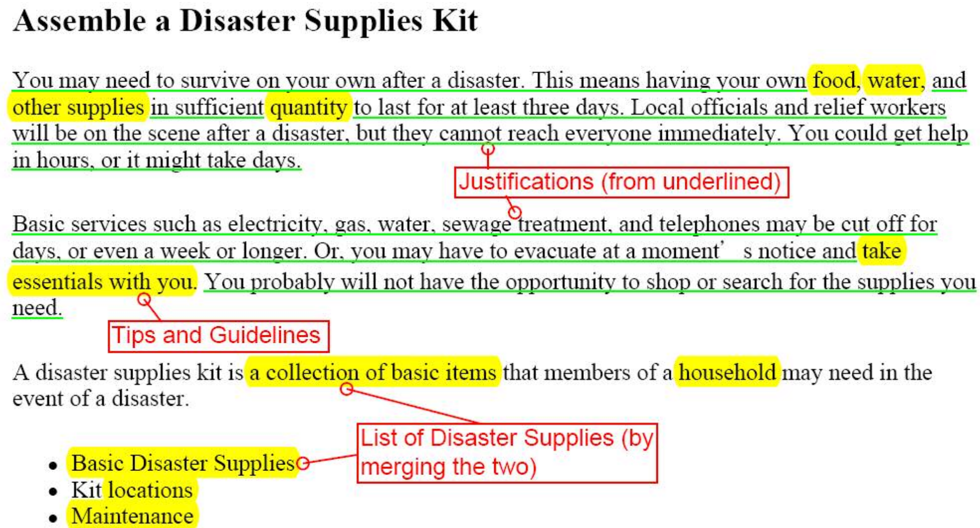
The following is an example of the process to construct “Supplies Kits Preparation” in ontology structure. Step 1 and Step 2-1: Figure 1 shows a webpage from Fema. Step 2-2: We identify and categorize web elements of the page. Enumeration of terms for web elements is a subjective process to capture concepts and key terms (Noy and McGuinness 2001). The concepts or terms may or may not appear in the original page. For example, some concepts and terms such as quantity, lists of disaster supplies, food, and water can be captured from the first paragraph in Figure 1 (marked in yellow highlight). The concept “lists of disaster supplies” is created for categorization per the grounded theory. To construct the hierarchical structure, we branch out the nodes from general to specific. These concepts and terms are thus represented by elements of XML in a hierarchy and finally the corresponding XML Schema is kept in DOM graph, Figure 2a. The DOM in Figure 2a is added to the inventory.

Assume that at some point in the process, we come across a page (Red Cross in Figure 3) that has similar web element instances. Step 2-2 is carried out for this page and the XML and DOM are generated, as in Figure 2b. Step-2-3: Through constant comparison processes of grounded theory, the structure created by Red Cross (Figure 2b) is compared and merged to the existing ontology structure with the same concept (Figure 2a). Figure 4 shows the outcome of comparison and integration.

The same process is repeated for all websites. Figure 5 shows the ontology structure for “Supplies kit Preparation” after the rest of websites are compared and contrasted.

This process was repeated many times as the elements of webpages in 100 websites were compared, contrasted, graphed, and categorized into the ontology structure. At the general preparation stage, the first level includes Individual Preparations and Business Preparations. At the Individual Preparation branch, the second level includes: Protection Plans, Evacuation Plans, Supplies Kit Preparation, Signals & Warning Systems, Security, Practice Plans, and Disaster Information & History. Under each node in the second level, specific web elements are identified within the hierarchy. For example, Supplies Kit Preparation, an example used in this paper, is one category that has 29 elements and four levels under it (Figure 5). Other categories have their own sub-structures with web elements and levels that have emerged from the process. The Business Preparations node was created, but is not completed since government websites have limited information regarding business preparations. This node is, therefore, a placeholder for future extensions of the ontology structure for business disaster preparedness. In the preparations for a specific disaster stage, we have two main categories at the first level: Common to all Disasters, Specifics to the Disaster. The elements are then identified under each node.

As structured, the ontology is flexible and extendable. It is expected to continuously evolve as new web elements emerge and has the potential to become a collective knowledgebase of web elements for disaster management.


Assemble a Disaster Supplies Kit

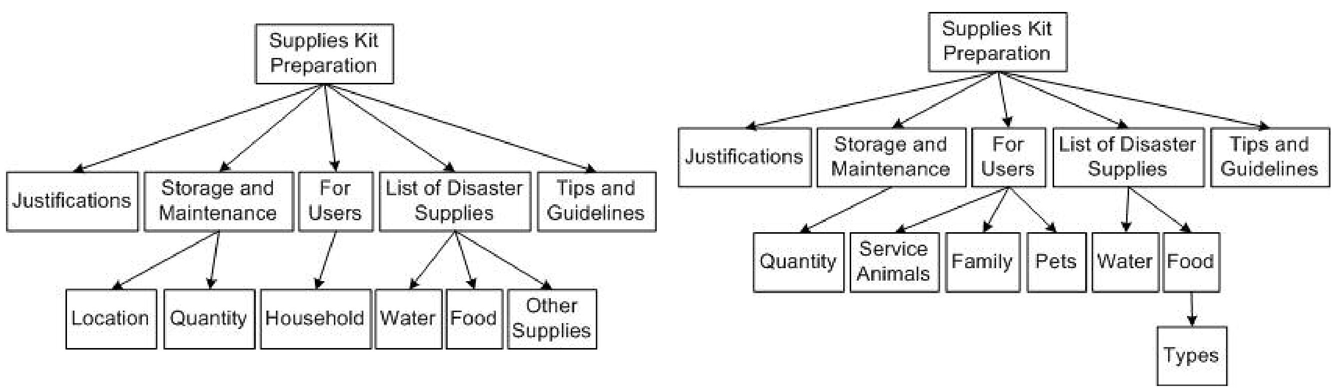
You may need to survive on your own after a disaster. This means having your own food, water, and other supplies in sufficient quantity to last for at least three days. Local officials and relief workers will be on the scene after a disaster, but they cannot reach everyone immediately. You could get help in hours, or it might take days.

Basic services such as electricity, gas, water, sewage treatment, and telephones may be cut off for days, or even a week or longer. Or, you may have to evacuate at a moment' s notice and take essentials with you. You probably will not have the opportunity to shop or search for the supplies you need.

A disaster supplies kit is a collection of basic items that members of a household may need in the event of a disaster.

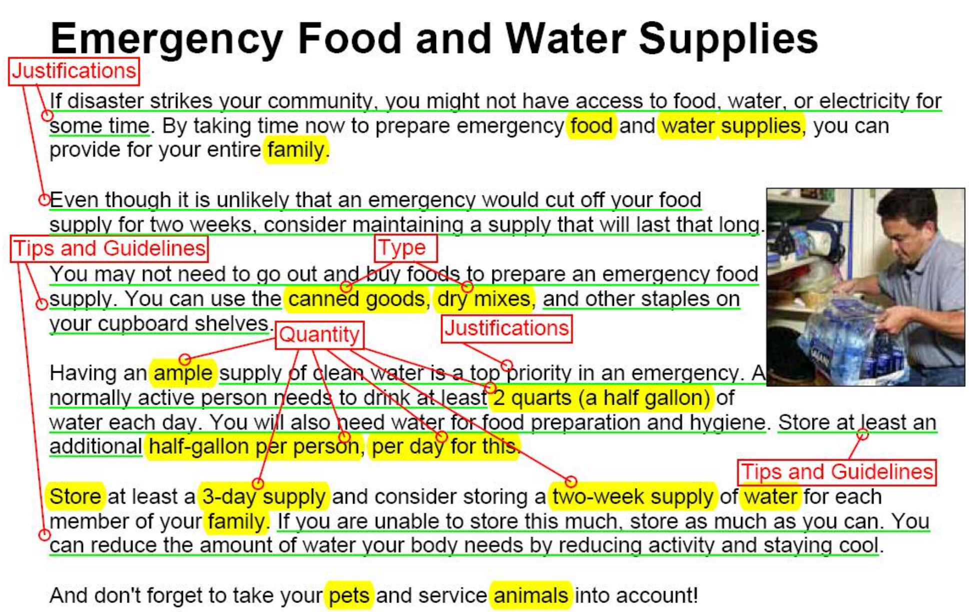
- Basic Disaster Supplies
- Kit locations
- Maintenance

Figure 1: A Portion of a Page from FEMA (source: http://www.fema.gov/plan/prepare/supplykit.shtm)



(a) (b)

Figure 2: Schema DOMs for Figure 1 and Figure 3.


Emergency Food and Water Supplies

If disaster strikes your community, you might not have access to food, water, or electricity for some time. By taking time now to prepare emergency food and water supplies, you can provide for your entire family.

Even though it is unlikely that an emergency would cut off your food supply for two weeks, consider maintaining a supply that will last that long.

You may not need to go out and buy foods to prepare an emergency food supply. You can use the canned goods, dry mixes, and other staples on your cupboard shelves.

Having an ample supply of clean water is a top priority in an emergency. A normally active person needs to drink at least 2 quarts (a half gallon) of water each day. You will also need water for food preparation and hygiene. Store at least an additional half-gallon per person, per day for this.

Store at least a 3-day supply and consider storing a two-week supply of water for each member of your family. If you are unable to store this much, store as much as you can. You can reduce the amount of water your body needs by reducing activity and staying cool.

And don't forget to take your pets and service animals into account!

Figure 3: A Portion of a Page from American Red Cross
(source: http://www.redcross.org/preparedness/cdc_english/foodwater-1.asp)

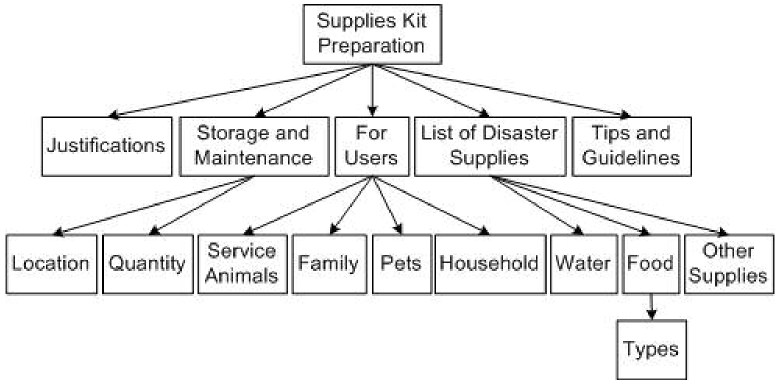


Figure 4: Schema DOM Obtained by Integrating DOMs in Figures 2a and 2b.

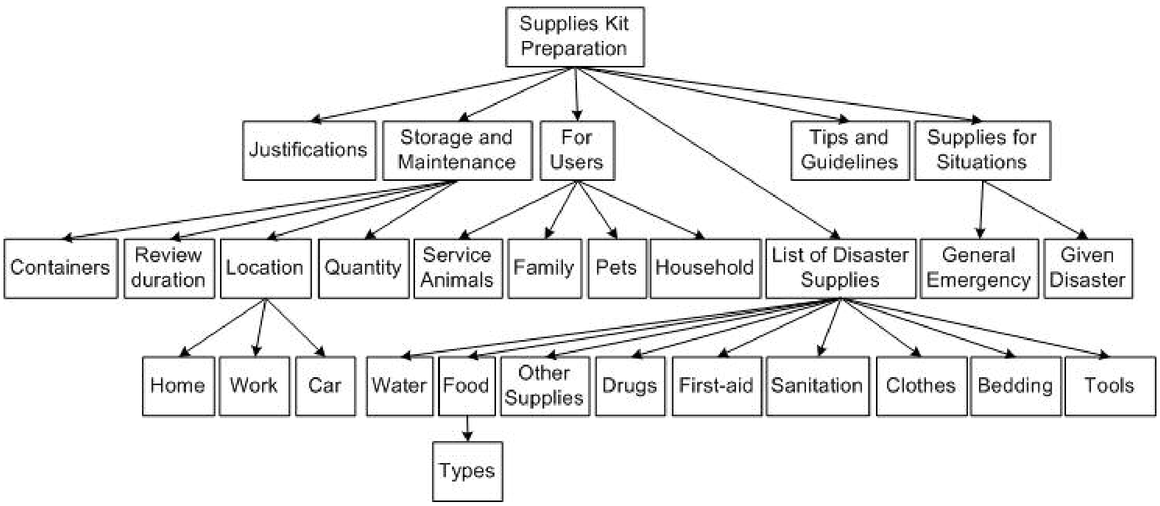


Figure 5: Schema DOM for "Supplies Kit Preparation" Based on All Websites

Implementing the Web-Based Ontology Structure (WB-OS)

Since the emerging ontology structure is large and complex, we need a tool to store and visualize it. Therefore, we developed the web-based ontology structure (WB-OS) to implement the storage and visualization of the ontology structure. We used XML DOM to visualize and traverse the structure as a tree. XML DOM is a platform independent and language independent standard, thus DOM can be implemented in any programming language and operated on any platform. We utilized a Java implementation of DOM, called Xerces (http://xerces.apache.org/xerces2-j/), to traverse the created Ontology Structures by XML and XML Schema. With the implementation of WB-OS by XML and XML Schema with DOM, web elements could be explored by traversing the DOM tree. For example, general understanding of disaster preparedness can be viewed by browsing upper levels of the tree, while deeper knowledge can be built by traversing more deeply through multiple levels of the tree. This tool is accessible on the web. Figure 6 is a snapshot of WB-OS, which was implemented on our Website, displaying a portion of ontology structure for the general disaster preparation.

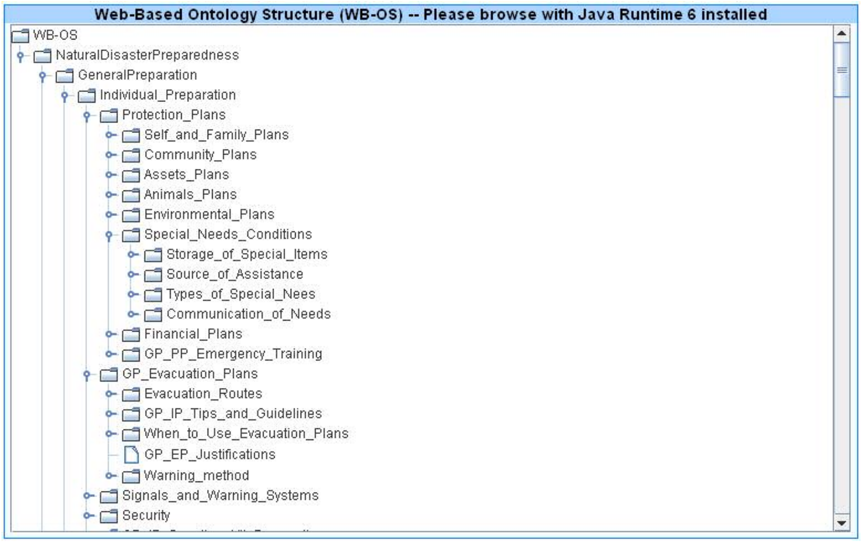


Figure 6: A Portion of Ontology Structure in Our WB-OS

Discussion

This study had three research questions. The first question was related to the choice of appropriate technology for managing the large and complex structure of web elements needed for creating WB-NDPS. Our survey and evaluation of existing semistructured data modeling and schema representation technologies led to the choice of the XML + DOM + XML Schema technologies for the discovery, modeling, and implementing the ontology structure for web elements needed in WB-NDPS.

The second research question was related to the identification of the web elements and ontology structure for WB-NDPS. By combining the grounded theory approach and the selected technologies, we developed the process to identify and categorize the WB-NDPS web elements into a well-structured ontology.

The third research question was whether the complex ontology structure of these web elements could be implemented into a web-based tool. Again, relying on the selected technologies and using the manifested ontology structure, we were able to create a web-based tool (WB-OS). WB-OS is a valuable tool since it could be used as a guideline in creating WB-NDPS websites as well as in evaluating the existing websites. Web developers and managers could use this tool in creating web-based natural disaster preparedness systems. They can also use it for checking and evaluating the sufficiency and comprehensiveness of their sites. It also could be used to benchmarking existing and future disaster Websites. Hence it can contribute to the education and evaluation processes in creating web-based disaster preparedness systems. Furthermore, our approach shows how one can model complex and semi-structured domains about which little knowledge is available.

Limitations and Future Direction

In this work, we addressed a portion of web elements needed for creating web-based natural disaster preparedness systems. We tackled the first two stages of disaster management: general and specific disaster preparedness. There remains a great deal of work to be done in completing the ontology structure for the rest of the three stages, disaster in progress, disaster recovery, and learning stages. Furthermore, our work is limited to governmental and non-profit websites. More work is needed for developing the ontology structure for business disaster management. The work should be extended to other types of disasters. In addition, this work reports the hierarchy of the needed web elements in a human-readable ontology structure, which could assist developers of natural disaster management. Such ontology structure can be further explored with machine readable languages RDF (http://www.w3.org/RDF/) and OWL (http://www.w3.org/2004/OWL/) to develop Websites that could exchange information and perform machine reasoning.

Furthermore, our WB-OS tool is a knowledgebase that could be used to quantify the adequacy and structure of existing disaster management websites and to recommend measure that could be taken to deal with inadequacy of structure and web elements. Since its structure is extendable, others may contribute to it by adding new categories and elements. Yet another direction of research is the evaluation and testing of the quality our ontology structure.

Our work has opened a new venue in modeling web elements for complex and semi-structured domains and in creating guidelines and tools that would assist the developers and evaluators of websites in such domains.

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