Knowledge Management Systems Developed For Hurricane Katrina Response

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ABSTRACT

This paper explores the use of knowledge management with emergency information systems. Two knowledge management systems that were utilized during Hurricane Katrina response are described and analyzed. The systems specified were developed by both federal agencies as well as grass root efforts without the support or mandate of government programs. These programs, although developed independently, were able to share data and interact in life saving capacities, transcending traditional geo-political boundaries. We conclude that emergency information systems are enhanced by incorporating knowledge management tools and concepts.

Keywords
Katrina, Hurricane Response, Knowledge Management Systems, PeopleFinder, ShelterFinder.

INTRODUCTION

On August 27th, 2005, President George W. Bush declared a state of emergency for three coastal states days before the August 29th landfall of Hurricane Katrina. Mississippi, Alabama, and Louisiana would be the site of the worst natural disaster in U.S. history, stretching government resources far beyond their ability to respond to the instantaneous and growing number of casualties. Running out of shelter and supplies for the growing number of victims, the government became logistically overwhelmed and under-equipped. Private citizens and companies (all Non-Government Offices) responded immediately. Multiple independent, yet collaborative by design, knowledge management systems were developed and implemented for immediate use to help victims find housing, medical supplies, post requests for immediate evacuation, as well as help find those separated in the storm. Via the Internet, people as far north as Michigan were able to help find housing in Washington State for people in southern New Orleans. This paper proceeds to describe how theses systems were developed, implemented, and used. We will describe the situation that led to the need of these systems, how these systems were created, the resources required for each, which category of knowledge management system each falls within, use of the systems by the end users, and finally describe the end result of these systems.

BACKGROUND

Before discussing the systems designed to aid Hurricane Katrina response it is important that we establish what we mean by knowledge, knowledge management, and a knowledge management system as well as provide a framework for how knowledge management fits into disaster or emergency response.

Knowledge

Davenport and Prusak (1998) define knowledge as an evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. Knowledge often becomes embedded in documents or repositories and in organizational routines, processes, practices, and norms.

Knowledge is also about meaning in the sense that it is context-specific (Huber, Davenport, and King, 1998). Jennex (2006) extends the concepts of context to also include associated culture that provides frameworks for understanding and using knowledge. A simpler definition of knowledge is that it is the how and why of something. It is the insight into why something happens that creates knowledge. To be useful though, this knowledge needs to be framed in context and culture, the information and data that explain how the knowledge was generated, what it means, and how it should be used.

Knowledge Management

Jennex (2005) defines knowledge management, KM as the practice of selectively applying knowledge from previous experiences of decision-making to current and future decision making activities with the express purpose of improving the organization's effectiveness. KM is an action discipline; knowledge needs to be used and applied for KM to have an impact. A knowledge management system, KMS, is the system developed to aid knowledge users in identifying, retrieving, and using knowledge they need. The following section further defines a KMS.

Knowledge Management Systems

Alavi and Leidner (2001, p. 114) defined a KMS as "IT (Information Technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT (Information and Communication Technology) system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application. Stein and Zwass (1995) define an Organizational Memory Information System (OMS) as the processes and IT components necessary to capture, store, and apply knowledge created in the past on decisions currently being made. Jennex and Olfman (2004) expanded this definition by incorporating the OMS into the KMS and adding strategy and service components to the KMS. We expand the boundaries of a KMS by taking a Churchman view of a system. Churchman (1979, p. 29) defines a system as "a set of parts coordinated to accomplish a set of goals;" and that there are five basic considerations for determining the meaning of a system:

- System objectives, including performance measures
- System environment
- System resources
- System components, their activities, goals and measures of performance
- System management.

Churchman (1979) also noted that systems are always part of a larger system and that the environment surrounding the system is outside the system's control, but influences how the system performs. The final view of a KMS is as a system that includes IT/ICT components, repositories, users, processes that use and/or generate knowledge, knowledge, knowledge use culture, and the KM initiative with its associated goals and measures.

Key to the KMS is a strategy that determines what knowledge is captured, how well the KMS performs the mnemonic functions of search, retrieve, manipulate, extract, and visualize, and knowledge repositories. Ultimately there are three types of knowledge repositories: paper documents, computer based documents/databases, and self memories:

- Paper documents incorporate all hard copy documents and are organization-wide and group-wide references that reside in central repositories such as a corporate library. Examples include reports, procedures, pictures, video tapes, audio cassettes, and technical standards. An important part of this knowledge is in the chronological histories of changes and revisions to these paper documents as they reflect the evolution of the organization's culture and decision-making processes. However, most organizations do not keep a separate history of changes, but do keep versions of these documents.
- Computer based documents/databases include all computer-based information that is maintained at the work group level or beyond. These may be made available through downloads to individual workstations, or may reside in central databases or file systems. Additionally, computer documents include the processes and protocols built into the information systems. These are reflected in the interface between the system and the user, by who has access to the data, and by the formats of structured system inputs and outputs. New aspects of this type of repository are digital images and audio recordings. These forms of knowledge provide rich detail but require expanded storage and transmission capacities.
- Self-memory includes all paper and computer documents that are maintained by an individual as well as the individual's memories and experiences. Typical artifacts include files, notebooks, written and un-written

recollections, and other archives. These typically do not have an official basis or format. Self-memory is determined by what is important to each person and reflects his or her experience with the organization.

Repositories can overlap each other, as an example, the computer repository stores the specific knowledge but the context and culture needed to use the knowledge is captured in paper procedure documents used to guide the knowledge use and in the mind of the knowledge user as a result of training in how to use the knowledge. Other examples include paper documents being indexed or copied into computer databases or files, self memory using paper and computer based documents/databases, and computer databases or files being printed and filed. Typically it is desired to capture as much knowledge as possible in computer and paper based memories so that the knowledge is less transient. It would be expected that organizations that are highly automated and/or computerized would be expected to have a greater dependence on computer-based repositories while less automated organizations may rely more on paper or self-memory based repositories.

Knowledge Management Systems and Emergency Response

Jennex (2004) identified an expanded model of an Emergency Information System, EIS. This model considers an EIS as more than the basic components of database, data analysis, normative models, and interface outlined by Belardo (1984); adding trained users, methods to communicate between users and between users and data sources, protocols to facilitate communication, and processes and procedures used to guide the response to and improve decision making during the emergency. The goals of the EIS are to facilitate clear communications, improve the efficiency and effectiveness of decision-making, and manage data to prevent or at least mitigate information overload. EIS designers use technology and work flow analysis to improve EIS performance in achieving these goals. Turoff, et al. (2004) expanded the expanded EIS model by introducing the concept of a dynamic EIS and identifying design requirements that expanded EIS capabilities in group communication and data/information/knowledge management. The result is that the focus of an EIS is on communication and facilitating decision making; both are also key attributes of a KMS.

Additionally, in recent years, disaster managers have realized the potential of KMS for faster and more organized response to natural disasters. The large number of groups that respond to a disaster all need access to a wide range of real-time information, requires coordination. Groups have proposed and created KMS that allow for more efficient use of data and faster response. One example that has been proposed is the Information Management System for Hurricane disasters (IMASH) (Iakovou and Douligeris, 2001). IMASH is an information management system based on an object-oriented database design, able to provide data for response to hurricanes. IMASH was designed with the premise that the World Wide Web is the medium of choice for presenting textual and graphical information to a distributed community of users. This design is much more effective in the fast-changing environment of a natural disaster than the historical use of static tools which, out of necessity, have been the tools used in disaster response. Kitamato (2005) describes the design of an information management system, Digital Typhoon, designed to provide a hub of information on the Internet during a typhoon disaster. The Digital Typhoon provides access to information from official sources (news, satellite imagery) as well as a forum for individuals to provide information (local, personal). It effectively became a hub of information, but created questions about organization, filtering, and editing. Systems used for Hurricane Katrina response realized the benefits and difficulties of these systems. Like IMASH, the systems described below use the Internet to distribute data to a community of users, and like the Digital Typhoon, the knowledge management systems described for Hurricane Katrina response became hubs of information that required data management to reduce repetition and allow for editing.

In summary, there is a fusion of EIS with KMS. This is because decision makers, when under stress, need systems that do more than just provide data, they need systems that can quickly find and display knowledge relevant to the situation in a format that facilitates the decision maker in making decisions. It is expected that EIS evolution will continue to utilize KM concepts and approaches as experience in responding to disasters is showing that these systems are more effective than traditional EIS. Examples of how KM aids emergency response includes using knowledge of past disasters to design communication and data/information capture protocols and templates, capturing emergency response knowledge in procedures and protocols; incorporating lessons learned into response team training, interface and display design, and the generation of heuristics guiding decision making; and using knowledge to guide the creation of experience knowledge bases that responders can use to generate emergency response actions. The rest of this paper illustrates how KM can help disaster response by looking at two systems used in response to Hurricane Katrina.

PEOPLEFINDER

Problem Emerges and Information Overload Occurs

During the first days after Hurricane Katrina hit the Gulf Coast, the Gulf Coast News website (http://www.gulfcoastnews.com) had setup a webpage for people to talk about their hurricane stories. Obviously geared for stories talking about how New Orleans spent a few days without power, the site quickly became an online repository for people to look for victims and post requests for help. Posts on the website ranged from asking for directions out of town, to people from other states asking if someone can check on or save their family members at flooded addresses. This trend grew, and quickly 23 different websites had people posting that they survived, as well as people looking for information on victims that had not been found. Anyone looking for loved ones would have to check each website as there was, at that time, no central repository for information. There also lacked a way to leave contact information should your search query be matched. As Table 1 indicates, many websites hit upon the same idea at the same time to host servers for survivors to post their status to. Although this was a terrific response from mostly civilian Internet companies, it created confusion on which sites to post to and search at, which created the need for a site like PeopleFinder (PeopleFinderTech, 2005).

Website	Number of Entries
http://www.msnbc.msn.com/id/9159961/	143,000
http://www.familylinks.icrc.org/katrina/people	135,222
http://wx.gulfcoastnews.com/katrina/status.aspx	42,477
http://www.publicpeoplelocator.com/	37,259
http://www.katrina-survivor.com/	9,071
http://www.lnha.org/katrina/default.asp	4,500
http://connect.castpost.com/fulllist.php	2,871
http://www.findkatrina.com	2,474
http://www.katrinasurvivor.net	2,400
http://theinfozone.net	1,300
http://www.cnn.com/SPECIALS/2005/hurricanes	1,120
http://www.wecaretexas.com/	200,000
http://www.scribedesigns.com/tulane/	1,933

Table 1. Websites and the number of survivor records each held (PeopleFinderTech, 2005**)**

Proposed Knowledge Management Solution

David Geihufe of the Social Software Foundation had been working on an open source Customer Relationship Management (CRM) system called CiviCRM (Geihufe, 2005). During the intelligence phase (Kersten, Mikolajuk and Yeh, 1999), David envisioned using his CRM system to create a web based, data driven DSS (Power and Kaparthi, 2002) form of knowledge management system that would be a central repository for victims and people looking for them. The website would accept data in an open standard from other websites, as well as allow people to post information directly to the server. Not having the resources necessary to use this system, David received corporate support from the Salesforce Foundation. In 24 hours, the Salesforce servers were accepting PFIF (PeopleFinder Interchange Format). Twenty-four hours after that, sixty thousand records had been inputted by global volunteers to the PeopleFinder knowledge management system Some inputs were parsed ('scraped') from sites such as Craigslist, and the Gulf Coast News. . Ultimately, over 620,000 records were searchable and over 500,000 searches processed. Tables 2 and 3 show the database schema.

NOTE Table	
string	**note_record_id**
string	person_record_id
string	linked_person_id
date	entry_date
string	author_name
string	author_email
string	author_phone
bool	found
string	email_of_found_person
string	phone_of_found_person
string	last_known_location
text	text

Table 2. The Note Schema (Lal, Plax and Yee, 2005) Note_record_id is the primary key

The note table is necessary as it is a lesson learned from the September 11th World Trade Center attacks (Lal et al., 2005). Entries may be updated multiple times, and syncing data between servers can become very difficult. The notes table solves this problem by keeping a log of who has made what change, and what changes were made. The timestamp on each file can be used as a quantitative metric on which entry is the most recent.

PERSON table	
string	**person_record_id**
date	entry_date
string	author_name
string	author_email
string	author_phone
string	source_name
string	source_date
string	source_url
string	first_name
string	last_name
string	home_city
string	home_state
string	home_neighborhood
string	home_street
int	home_zip
string	photo_url
text	other

Table 3. The Person Schema (Lal et al., 2005) Person_record_id is the primary key

Integrity of data, a key component of a successful DBMS (Database Management System), while syncing between multiple servers was non-trivial. Multiple approaches were considered, and the decision was made to keep all data sets as read-only throughout the entire transaction process, except for the field entry_date, which would indicate when that entry had been posted to the server. (Lal et al., 2005)

Figure 1 shows the data flow diagram depicting how the data transverses the system. Table 4 details the decision table providing a rule set for when to manually enter the data into the PFIF repository, and when to request to have a parser written.

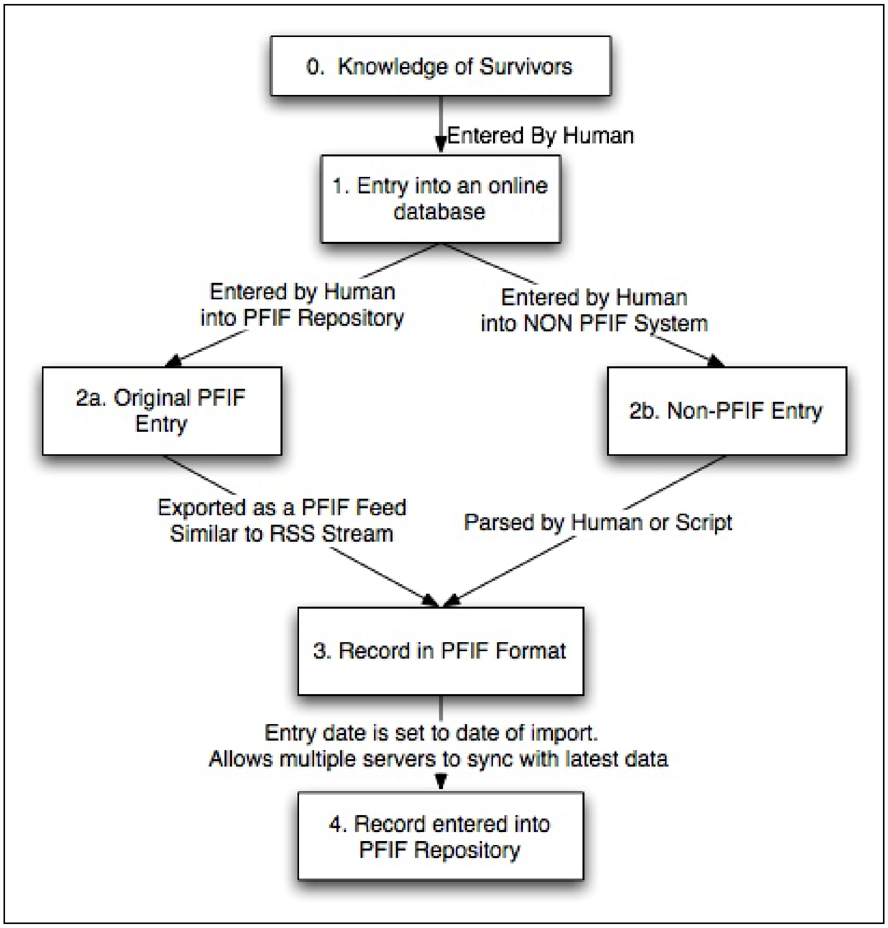

Figure 1. Data Flow Diagram (based on Lal et al., 2005)

Potential Conditions	Actions to be performed		
	Manual entry	Task a parser for later development	Task a parser for immediate development
If (postings) <25	X		
If (postings) <25 but anticipate growth	X	X	
If (postings) > 25		X	
If (postings) > 100			X

Table 4. Decision Table for assessing how to proceed with new websites discovered.

Leaderless Development

A wiki was used to coordinate tasks and development for the PeopleFinder system. A wiki is a "A website or similar online resource which allows users to add and edit content collectively" (Parlament of Victoria, 2005). The wiki originated in 1994/1995 (Cunningham, 2005), but has only recently come to live as a content management system (Mattison, 2003) and be applied as a tool for improving emergency response (Raman, Ryan, and Olfman, 2006).

Anyone wanting to make changes to the wiki had to register on it. Similar to public bulletin board websites, registration was automated and required no formal approval (Aronsson, 2002). When a developer found bugs or noticed new features that needed to be added to the system, they could post a task that needed to be completed. One of the other developers could assign themselves to the task to complete it, give status on its development, and clear the task upon completion. Sites to be scraped were handled like this as well. Sites that had information to share could be listed on the wiki, and people could either manually transfer the information record by record, or coders could write parsers to grab the information and repost it into the SalesForce server in PFIF. The determination on whether to manually parse the site, or write a parser for it was determined by the number of entries on the site, the number of entries expected on the site, and whether or not the author of the original site had made safeguards to prevent scripts from parsing the site (PeopleFinderTech, 2005).

With any website that can be modified by the general public, vandalism is an immediate and valid concern. For example, there was nothing to keep political protestors from registering and defacing the website with a political message that has nothing to do with the purpose of the website. Fortunately, editors on the website kept vandalism suppressed by monitoring the RecentChanges page (Tanaka, 2005).

Analysis

PeopleFinder went from an idea to operationally functioning within a 72-hour window. Due to the nature of the website, few users would be inclined to leave feedback to make the site more helpful. Therefore, features may have been incorrectly prioritized based on what the developers thought would be helpful, rather than what the user base needed. Future concerns about this type of project will most likely include privacy rights. When someone wants their online entry removed from the database, perhaps to avoid any risk of identity theft, there is currently no feature that allows them to be removed. In fact, the data network is setup to maintain the entries at all cost. It is also difficult to have an easy-to-use website that allows distraught people to find their family and friends, while making sure that those with criminal intentions are filtered out. Regardless of the security downfalls, PeopleFinder was a success as soon as the first person was able to quickly ascertain the status of a loved one.

KM use in PeopleFinder is reflected in its construction. The system itself reflects the capture of lessons learned and is itself a repository of knowledge. Knowledge capture and use is also reflected in the capture of notes and the history of notes for each person. KMS features implemented in the system include knowledge repositories and the implementation of good mnemonic functions (search, retrieve, visualize). As stated it was not expected that feedback would be left by users, this needs to be compensated by researchers who need to collect some system satisfaction data so that future systems can learn from mistakes in this system.

SHELTERFINDER

FEMA estimated that over 500,000 people were left homeless, and another 500,000 jobless (California Political Desk, 2005) by Hurricane Katrina. With that many people residing in such a close proximity to each other, finding a new place to live, even for a temporary amount of time, can be near impossible. Employment in other cities could be located online through already existing jobs databases, however there was no way to find somewhere to live for free during the victims' rebuild from devastation. At the same time, hundreds of thousands of people across the nation offered up their homes to let Katrina victims have somewhere to stay until they could find permanent housing. The problem was how to coordinate information so that people who were in the affected areas could find housing across the nation. Like PeopleFinder, multiple websites began to popup to offer housing, but there was no organized meta search, allowing users to check one centralized location.

Collecting Shelter Data for Hosting

ShelterFinder (2005) was set to solve the same problem as PeopleFinder. Continuing with open standards for the systems data formats, ShelterFinder maintained a means for a single server to stream new data feeds to multiple servers, while simultaneously being ready to respond to requests for data from other servers. Rather than PFIF that was designed for victims, ShelterFinder used standard formats such as CSV (Comma Separated Values) and XML (Extensible Markup Language) (Walsh, 2003). These formats allowed an independent team of developers to write database search systems as well as another independent team to build the GIS front end for more efficient use of the database system. Like PeopleFinder, a wiki was used for distributed management of the project. ShelterFinder would become a web based, data driven DSS (Power and Kaparthi, 2002) form of knowledge management system.

Analysis

ShelterFinder gained huge acceptance due to two major components. First, it was a combined search engine that hosted records for more homes or shelters than most housing search engines. Letting the victims choose a specific city, even if it is on the opposite side of the United States away, allowed victims to try to find temporary housing near family or in areas they might be able to get jobs. This helped the families find shelter near helpful social resources, while decreasing the stress that the increased number of people could inadvertently cause on the resources of an area. When large amounts of people have been displaced, any opportunity to place them in different geographic areas helps the relief effort.

Second, the GUI was uniquely easy to use and made finding homes or shelters near specific addresses incredibly easy and intuitive. The GUI was a result of the recent introduction of Google Maps (http://maps.google.com/). Using built-in Google Maps XML parsing engine, it provided a graphical front-end allowing users to see where in America homes were available, as well as an intuitive graphical representation on the map of how many spaces were free at each shelter based on icon color. At a community level, Google Maps has developed a means for conventional GIS developers to become web-based GIS developers and create web-based applications, quickly and cheaply.

KM use in ShelterFinder is also reflected in its construction. The system itself reflects the capture of lessons learned and is itself a repository of knowledge. However, this system is actually a reflection of a failure to capture and use knowledge. The system should have been designed to capture and use knowledge of survivor preferences and housing and service characteristics to obtain better fits of survivors to available housing other than fits based on location. Allowing searchers to pick locations that they thought best is convenient, but not ideal as reflected in reported dissatisfaction with survivors in a number of communities that took in and housed survivors. A key issue was the widespread dispersion of current or former criminals to locations who did not know what they were getting. Knowledge use could have mitigated these issues. KMS features implemented in the system include knowledge repositories (although they were weak repositories based on location knowledge) and the implementation of good mnemonic functions (search, retrieve, visualize).

CONCLUSION

Even as recently as the Sumatra-Andaman earthquake of 2004, disaster management response required printed maps, and specially trained disaster management personnel to coordinate the deployment of resources. Military groups such as the US Army's Civil Affairs branch and NGOs such as the American Red Cross, have specially trained personnel to sort through the overwhelming amounts of information that arrives and interact directly with victims. The incoming information arrives in a variety of formats, inconsistent for the operations center, but usually in a consistent format from each source. This type of work usually requires specialized operations centers, a specialty staff to manage the data, and requires significant time to sort through the paper records submitted from the disaster area. Everyday citizens that would like to contribute are unable to, not only because they are not inside the physical operations center but also because there was no way for responders to reach out to the community to look for resources. Knowledge management systems, such as IMASH and the Digital Typhoon, have been researched and developed to help coordinate response to disasters. However, only by assessing how these types of systems actually worked in a disaster can improvements be made and resources like these used most efficiently in the future.

The technologies discussed here are changing the traditional approach to disaster response. Conventional, expensive, and isolated operations centers are morphing into a series of scalable, cheap, distributed, and highly networked information portals that can be used wherever a computer and Internet access are available. The more wireless options that become available to people in disaster struck areas, from WiMax to satellite, the more options this new breed of distributed systems will have for helping people in real-time wherever tragedies strike.

The social approach of these two projects is fairly unconventional in comparison to both commercial America as well as traditional disaster response. Leaderless cells performing specific actions are historically more comparable to terrorist networks than they are humanitarian operations. The concept of groups self-determining their order of operations is countertraditional management approaches. However, the unsuccessful initial Hurricane Katrina response by the government (CNN, 2005) has shown that a rigid management can become overwhelmed when emergencies are too geographically widespread, or too many people have been affected. Distributed teams that can utilize knowledge management systems, and can dynamically call upon the continually growing user base of the Internet for expert resources and manpower, have a better chance to respond to the myriad of future emergencies.

Finally, the use of KM and KMS functions is shown to improve the speed and quality of response actions. This is expected and it is our conclusion that future EIS should incorporate KM considerations.

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