Who's Really on First?
A Domain-Level User, Task and Context Analysis for Response Technology

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ABSTRACT

This paper presents a domain-level user, task and context analysis for response technology, based on sociological studies of disaster and disaster response. The analysis examines three dimensions of disaster—scale, kind and anticipability—that have been linked to differences in response characteristics, including differences in individual and organizational responders and behaviors. It yields a number of implications for design, and reveals five domain-specific design requirements. It also offers systematic characterizations of users, tasks and contexts of response technology, that begin to structure the user interface design space, laying a foundation for a theory of design. This work provides a conceptual basis to help researchers and designers recognize and address possible limitations of design decisions, leading, ultimately, to more usable and effective response technologies.

Keywords

Requirements analysis, domain analysis, user interface design, disaster, emergency, crisis, management, response.

INTRODUCTION

Historically, the main contribution of technology to disaster has been to fail. That is, technology has mostly been part of the problem, if not its actual cause. This has changed with the advent of communications technology and, more recently, information systems, and technology increasingly contributes to disaster solutions. Research and design of technology for disaster management has, accordingly, emerged as a distinct field. However, like most nascent disciplines, this field has yet to develop a coherent body of theory to guide and inform its activities.

In the area of user interface research and design, the lack of theory is evident in widely disparate conceptions of who "the users" are, what they are doing, and where they are working. Many research and design efforts are based on idiosyncratic conceptions of "user," "task," and "context," that are often hypothetic, and sometimes, myopic. Such efforts fail to consider the fluid ambiguous nature of disaster, and the diversity of individuals who participate in disaster management. The resulting technologies may appear promising, but limitations imposed by underlying assumptions will ultimately hamper their usability and utility.

This paper presents a domain-level user, task and context analysis for *response technology*—technology to support the response phase of disaster management. The analysis is based on an extensive literature on the sociology of disaster and disaster response that links qualitative differences in response activities to characteristic differences in events, including differences in what individuals and organizations participate, what tasks must be performed and what conditions working environments offer.

The paper examines three dimensions of disaster—scale, kind and anticipability—that sociologists have linked to response characteristics. For each dimension, the paper reviews the sociological definitions and findings briefly, and then extracts specific implications for users, tasks and contexts of response technology. These implications are then used to develop systematic user, task and context characterizations, and the implications for design are discussed, revealing five domain-level design requirements (requirements that apply to all applications in the domain, but are peculiar to the domain). The literature reviewed—and the present analysis—takes a broad view of "disaster," using the term for events ranging from simple traffic accidents to catastrophic earthquakes.

The analysis offers insight into the complexities of the domain of response technology design, and explains why solving a technical obstacle—while critical—is only one step in developing effective tools. The systematic characterizations of users, tasks and contexts begin to structure the user interface design space, laying a foundation for a theory of design. It will help ensure that designers and researchers base their work on realistic assumptions, leading to more usable and effective response technology.

BACKGROUND AND RELATED WORK

User, task and context analysis is a form of requirements analysis, and is a widely accepted technique for improving the utility and usability of information technologies (Beyer and Holtzblatt, 1998; Hackos and Redish, 1998). It is typically applied at the application level to develop characterizations of anticipated users, tasks and working contexts. The present approach of conducting requirements analysis at the domain level is borrowed from software engineering (Prieto-Dìaz, 1990), and adapted by using human rather than computational tasks to define domains. Domain-level analysis for user interface design has also been applied to creativity (Hewett, 2005), navigation (Jul, 2004), and to develop domain-specific style guides (Gulliksen and Sandblad, 1995).

The present work complements the efforts of Chakrabarti and Mendonça (2005) who outline a domain-level analysis of stakeholder requirements for information systems for critical infrastructure management. It contrasts the work of Zimmerman (2006) who suggests ways of increasing the effectiveness of existing general-purpose technologies during response, by focusing on specialized response technologies.

The information used in the analysis derives from empirical studies of disasters and disaster responses, as reported in survey and synthesizing literature. The discussions of scale and kind of disaster are based on the work of Quarantelli (1993, 1998, 2005, 2006), Dynes (1998), and Kreps (1998), all of whom develop sociological theory from extensive field studies. Discussion of scale relies on reviews of studies of emergent social phenomena (Drabek and McEntire, 2002, 2003). The dimension of anticipability is the work of Gundel (2005), which rests on reports and analyses of actual disasters and responses.

It should be noted that most of the studies underlying the sociological literature were conducted in North America and examined responses to consensus-type events (such as natural hazard occurrences). Results of the present work consequently reflect American disaster management culture and practices, and may not generalize to other cultures. It should also not be assumed to apply to the remaining phases of disaster management—prevention, mitigation, preparedness and recovery—or to conflict-type events (such as civil conflicts or riots) without further analysis.

DIMENSIONS OF DISASTER

Sociologists have found that responses differ qualitatively, and that these differences can be linked to characteristic differences in the events themselves (Quarantelli, 1998). Three dimensions are particularly indicative of response characteristics: *scale* (a measure of the extent of the effects), *kind* (an indicator of the types of effects), and "*anticipability*" (a description of the possibilities for preparedness). Scale is particularly complex and comprises a variety of related measures.

Scale

Scale is a measure of the extent of the effects of an event, and reflects the power of the causal agent(s), the success of mitigative measures, and the effectiveness of the response system. Sociologists commonly discuss three measures of scale: magnitude, scope and duration of impact (Kreps, 1998). *Magnitude* indicates "the severity of social disruption and physical harm" (ibid., p. 34), in other words, the extent to which the lives of those affected have been interrupted or altered. *Scope* indicates "the social and geographic boundaries of social disruption and physical harm" (ibid.), that is, the size of the affected socio-geographic area. *Duration* is "the time lag between the onset of social disruption and physical harm and when the disaster is no longer defined as producing these effects" (ibid.), i.e., how long it takes for things to stop breaking.

Scope and duration are fairly straightforward (albeit difficult to measure), but Quarantelli (2005) separates magnitude into disruption of community infrastructure and resources (physical and human), disruption of response infrastructure and resources, and the adequacy of established response measures. He integrates these with scope and duration to define three distinct scales (cf. Table 1): An *emergency* is a short-lived event whose effects are localized within a single community. The community as a whole and its response infrastructure remain fully functional, and its internal capacity is sufficient to manage the response. A *disaster* is a longer-lived event that affects an entire community, but which leaves both community and response infrastructure largely intact. However, because so much of the community is affected, it is not able to manage the response on its own and must rely on aid from neighboring communities (typically through mutual aid agreements). A *catastrophe* is a long-lived event that affects multiple

	Emergency		Disaster	Catastrophic Disaster
	Local Emergency	Local Disaster		
Example	*1997 Paris traffic accident*	*2006 Mountain View apartment complex fire*	*9/11 Terrorist attack, 1989 Loma Prieta earthquake*	*1918 US flu epidemic, 2004 US hurricane season, 2005 Hurricane Katrina*
Impact on community infrastructure	Localized effects, if any		Localized damage or loss	Extensive damage or destruction
Impact on response infrastructure	Largely unaffected		Localized damage or loss	Extensive damage or destruction, and/or completely overwhelmed
Adequacy of response measures	Within local planning		Exceeds local capacity but within greater response capacity	Exceeds all planning and capacity
Organizational emergence	Only established organizations mobilized	Established and expanding organizations mobilized	All types of organizations mobilized	
Scope	Only part of single community and official jurisdiction affected		Single community and official jurisdiction affected	Multiple communities and official jurisdictions affected
Duration	Hours-weeks		Weeks-months	Months-years

Table 1 Measures of scale.

communities, destroying much of their infrastructures, and severely damaging or overwhelming response systems. Communities cannot manage the response on their own and often compete with neighboring communities for external assistance rather than benefiting from mutual aid agreements.

Responses to differently-scaled events differ in the amount of and dependence on emergent behaviors and organizations (spontaneous responses by individuals and organizations not normally engaged in disaster-related activities) (Drabek and McEntire, 2003; Quarantelli, 2005). The so-called "DRC typology" describes responding organizations in terms of the relationship between the organization's every-day activities and operating structure, and those it assumes during a response.

The typology identifies four types of organizations (Dynes, 1998; Table 2): *Established organizations* normally engage in response activities, and their operational structure is unchanged during responses. *Expanding organizations* routinely engage in response activities, however, they must expand their operational structure to do so, typically by recruiting volunteers. *Extending organizations* do not normally perform response activities, but are able to do so using their existing organizational structure. *Emergent organizations* likewise do not normally participate in response, but must create a new organizational structure to do so, and are often formed spontaneously.

What and how quickly different organizations are mobilized depends on the scale of an event (Dynes, 1998). Dynes distinguishes two types of emergency: *local emergencies,* which can be handled entirely by established organizations (e.g., most traffic accidents and single-family house fires), and *local disasters*, which require the involvement of an expanding organization (e.g., an apartment building fire that displaces all residents). In larger events, all four types of organizations are mobilized sequentially: established, expanding, extending and, lastly, emerging, with the first two activating nearly simultaneously in sudden onset events. As organizations mobilize, responders may be sent to different locations, and may transfer between locations as resources and operational needs change.

Although different organizations may be engaged in vastly different tasks, the involvement of diverse individuals and organizations imposes a need for partnership formation, with its attendant themes of cooperation and

		Tasks	
		Routine	**Non-Routine**
Operational Organizational Structure	**Same as pre-disaster**	I. Established (e.g., city emergency services)	III. Extending (e.g., church community providing meal service)
	New	II. Expanding (e.g., American Red Cross)	IV. Emergent (e.g., community group formed to collect donations)

Table 2 DRC Typology of organizations participating in response (Dynes, 1998).

collaboration (Drabek and McEntire, 2002; Dynes, 1998). Not surprisingly, partnership formation is essential to responses to events of all sizes except local emergencies, and grows increasingly critical as the scale of event increases (Quarantelli, 2005).

Table 1 summarizes measures of scale, and characteristics of events of different scales. Although differently-scaled events are qualitatively distinct, the scale of a particular event may not be apparent until the response is well underway (or even after it is concluded). Additionally, events may transition abruptly from one scale to another as contributing factors are compounded or uncovered.

Implications of Differences in Scale

The differences in responses to events of different scales have a variety of implications for users, tasks and contexts of response technology.

Organizations vary in regard to individual members' training and experience with disaster response. Members of established organizations are mostly "career" responders (e.g., police officers and paramedics), and may be presumed to have both training and experience with frequently-occurring response tasks. Expanding organizations typically have a small core of "habitual" responders (with both training and experience in response). This core is supported by a larger group with training but limited experience, and augmented (when fully mobilized) by a large number of individuals with neither training nor experience.

Members of extending and emergent organizations generally have little or no training or experience with disaster response, with two notable exceptions. First, in disaster-prone areas, such as the Philippines, some extending organizations are mobilized sufficiently often that response tasks become routine and the organization effectively functions as an established organization (Bankoff, 2002). Second, in large responses, established organizations may partner to form emergent organizations to address specialized demands (Drabek and McEntire, 2003).

Responses to local disasters, disasters and catastrophes thus typically involve semi-trained and untrained responders. Logically, the proportion of semi-trained and untrained responders increases with the scale of event, and they assume greater responsibility for response activities. In catastrophes, they may handle local responses entirely, with experienced responders not arriving until the recovery phase. And, even though local emergencies are handled by established organizations, "In 95 percent of all emergencies, the victim or bystander provides the first immediate assistance on the scene" (US Department of Homeland Security, 2006).

Additionally, as the scale of an event increases, more locations are affected, more facilities suffer extensive damage, and more non-local responders are brought in. Consequently, in larger events, many responders work in unfamiliar settings and, in catastrophes, many work in settings that offer few, if any, resources. Responders in catastrophic settings may depend solely on response-deployed technologies, and may not have access to external knowledge of available resources or standard procedures. Of course, the setting itself may change as infrastructure and access to external resources are restored.

Partnership formation offers an example of a *response-generated task*—tasks arising from the response itself. These are contrasted by *agent-generated tasks*—tasks deriving directly from the causal agent. This distinction is often overlooked (Dynes, 1998), but is important to design as support needs differ: agent-generated tasks typically require agent-specific training and support, whereas the skills and knowledge needed for response-generated tasks are independent of the causal agent.

The implications for users, tasks and contexts can be stated as follows:

Users

- Users can be characterized by their familiarity with disaster response, with individual users having extensive, some or little knowledge.
- It cannot be assumed, except perhaps in local emergencies, that the user has local knowledge (e.g., of geography, culture or resources).

Tasks

- Tasks can be characterized by their origins, with individual tasks being either agent- or response-generated.
- Agent- and response-generated are conceptually distinct, but may not be separate in practice, and individual users may perform both concurrently.

Contexts

- Contexts can be characterized by whether and which resources are functioning, with individual contexts offering normal infrastructure and tools, normal infrastructure only, normal tools only, or neither infrastructure nor tools.
- Contexts can be characterized by their similarity to environments known to the user, with individual contexts being very familiar, somewhat familiar, or unfamiliar.
- A given user, particularly in larger events, is likely to work in a variety of contexts, either because of physical relocation or because of changes in the context itself.

Kind

Sociologists have also found that event *kind* affects response characteristics (Dynes, 1998). Events are often characterized by causal agents (for instance, distinguishing between natural and man-made), but, for design purposes, a distinction based on effects is more useful. Dynes (1998) separates *community disasters*—events that affect a broad range of physical and human resources (e.g., earthquakes)—from *sector disasters*—events that primarily affect a specialized segment of the community (e.g., computer viruses). Most of the literature examined in the previous section on scope describes responses to community disasters.

Responses to sector disasters may not involve traditional response organizations, but may be handled by sector professionals, e.g., computer professionals in the case of a computer virus, or infectious disease epidemiologists in the case of a human virus. If established response organizations are mobilized, they may be providing support services only, for instance, managing crowd control or cross-jurisdictional response coordination. *Trans-system social ruptures (TSSRs)*—sector disasters that spread rapidly and erratically across geographically dispersed locations, crossing national and international boundaries (e.g., the SARS outbreak of 2003)—introduce a social heterogeneity that places a high demand on rapid partnership formation across both disciplinary and socio-political boundaries (Quarantelli, 2006).

Implications of Differences in Kind

Differences in responses to different kinds of events affect design in several ways. Response tasks—particularly agent-generated tasks—may require skills and knowledge that are unrelated to disaster response. Responders may need advanced knowledge of a specialized professional domain, if not actual knowledge of specific problems and solutions. Different kinds of events may also expose responders or response tools themselves to increased risk, e.g., in human epidemics, medical personnel may be infected at a higher rate than the general public, and, in dealing with a computer virus, the computational response tools may themselves be infected or vulnerable. If responders are vulnerable, unusual procedures may be introduced and a high number of non-local responders engaged. If responders' tools are vulnerable, responders may be working with unfamiliar or compromised tools (but in familiar settings).

The implications for users, tasks and contexts can be stated as follows:

Users

- Users can be characterized by their task-relevant knowledge, with individual users having task-specific, general domain, or little knowledge.

Tasks

- If response tasks require specialized knowledge, agent- and response-driven tasks may be performed by different individuals, potentially from different organizations.
- As agent- and response-driven tasks are separated, partnership formation becomes increasingly critical.

Contexts

- Users may be working with unfamiliar procedures or compromised tools, even in familiar, normally-functioning contexts.

Anticipability

The final dimension of disaster, *anticipability*, captures event characteristics that determine what preparedness is possible (Gundel, 2005). It comprises two measures, predictability and influenceability. An event is *predictable* if it is within the realm of imagination of the times, and its occurrence is perceived as sufficiently likely as to be believable. So, for instance, the events of the 9/11 Terrorist attack were not predictable because, to pre-9/11 social consciousness, using commercial airliners as bombs was both unimaginable and unbelievable (National Commission on Terrorist Attacks, 2004). An event is *influenceable* if means of reducing damage are known and can realistically be implemented given the resources and socio-political environment of the time and place. Thus, for example, although many measures had been proposed that would have reduced the impact of Hurricane Katrina, the socio-political environment of the preceding decades prevented many from being implemented.

These two dimensions result in four classes of events (Table 3). Gundel points out that, while responses to conventional events rely on planning and practice, preparation and responses for unexpected events requires improving information exchange and preparing disaster managers to contend with new and unexpected problems. Intractable events rely on organizational and political partnership formation, and, for fundamental events, Gundel advocates formation of expert groups to provide “think-tank expertise” to support preparedness and response.

Implications of Differences in Anticipability

Differences in anticipability show that events may generate novel problems and tasks, and place even experienced responders in unfamiliar situations. This means that responders as well as responding organizations may need to develop new procedures and structures, and may be working in unexpected settings. However, even ordinary problems may not be solvable in advance, requiring responders and responding organizations to develop and draw on new resources. The concept of influenceability also hints that events may be difficult to control, and response efforts may need to adjust to sudden changes in location, scale, or priorities.

The implications for users, tasks and contexts can be stated as follows:

Users

- Even experienced users may be working beyond their sphere of competence.
- Established and expanding response organizations may be functioning as extending or emergent

		Influenceability	
		Easy	**Hard**
Predictability	**Easy**	1. Conventional (e.g., 1986 Chernobyl)	3. Intractable (e.g., 2005 Hurricane Katrina)
	Hard	2. Unexpected (e.g., 1979 Three Mile Island)	4. Fundamental (e.g., 9/11 Terrorist attack)

Table 3 Measures of “anticipability” (Gundel, 2005).

organizations, i.e., performing non-routine tasks and developing new organizational structures.

Tasks

- Tasks can be characterized with respect to novelty, with individual tasks being either conventional or novel.
- Novel tasks may increase the criticality of inter- and intra-organizational partnership formation.
- Task prioritization may shift suddenly and dramatically.

Contexts

- Contexts may not be located or functioning as planned or expected, e.g., they may be more or less austere, operations may be established in novel locations, or response activities may be relocated unexpectedly.

IMPLICATIONS FOR DESIGN

The properties of users, tasks and contexts revealed by examining the three dimensions of disaster define a design space for response technology that refines the design space for conventional productivity tools.

In conventional user interface design, users are characterized in terms of task expertise and responsibilities (or "role") (Hackos and Redish, 1998). It is implicitly assumed that responsibilities are assigned according to expertise, so different levels of expertise can be accommodated with different designs for different responsibilities, and by making "expert features" less accessible. In response situations, task expertise comprises knowledge of both disaster response and the actual task the user is called upon to perform (Table 4). Responsibilities are often "assigned" by the vagaries of physical location, and it cannot be assumed that expertise is commensurate with responsibilities. It is thus not only desirable that a single design accommodate different levels of expertise, but that designs help users acquire necessary expertise. This suggests a design requirement that goes beyond the standard usability requirement for tool learnability:

> **Design Requirement #1:** Response technology should seek to support just-in-time learning, first, of the task the tool is intended to support, second, of the needs and goals of the present operation, and, third, of disaster management practices in general.

This can be accomplished through designs that foster collateral (learning-while-doing) and collaborative (learning-together) learning, and support adaptive expertise (application of knowledge of similar but unrelated tasks).

Tasks, in conventional design, are characterized in terms of their goals (Hackos and Redish, 1998), and are, in general, too diverse to be described at the domain level. In disaster response, tasks can be distinguished by their origin and novelty (Table 5). These dimensions dictate the training and support they require, which, in turn, dictate the generality and flexibility needed in designs. Training and tools for agent-generated tasks are only applicable to events with similar causal agents, while training and tools for response-generated tasks apply to events requiring similar responses. In practice, however, responders often undertake both types of tasks concurrently, suggesting that:

> **Design Requirement #2:** Response technology, even when focused on agent-driven tasks, should seek to aid response-driven tasks, such as planning, coordination and resource management.

As has been seen, partnership formation is so pervasive and critical a task that it emerges even at the domain level, and demands its own design requirement:

> **Design Requirement #3:** All response technology should actively nurture cooperation, collaboration and partnership formation.

The dimension of task novelty is more problematic from a design perspective: On the one hand, to support conventional tasks, designs must impose and enforce standard structures and procedures. On the other hand, support for novel tasks must allow creativity and innovation with respect to both structure and procedure. Unfortunately, the novelty of particular task may not be apparent until it arises in actual events, so it is not possible to predict the novelty of the task the tool must support, suggesting a paradoxical requirement:

> **Design Requirement #4:** Response technology, while imposing standard structures and procedures, must, insofar as possible, allow flexibility and deviation in their application.

		Task-Relevant Knowledge		
		Task-Specific	General Domain	Little
Knowledge of Disaster Response	Extensive	Super-expert	Functional semi-expert	Functional inexpert
	Some	Expert	Semi-expert	Functional inexpert
	Little	Specialist	Semi-specialist	Inexpert

Table 4 Types of users.

		Novelty	
		Conventional	Novel
Origin	Agent-Generated	Basic	Phenomenal
	Response-Generated	Sustaining	Exceptional

Table 5 Types of tasks.

		Austerity			
		Infrastructure and Tools	Infrastructure Only	Tools Only	Limited or None
Familiarity	Very	Known normal	Known severe	Known harsh	Known extreme
	Somewhat	Familiar normal	Familiar severe	Familiar harsh	Familiar extreme
	Unfamiliar	Unknown normal	Unknown severe	Unknown harsh	Unknown extreme

Table 6 Types of contexts.

Contexts are, in conventional design, typically characterized in terms of social setting (home, office, public, etc.) (Beyer and Holtzblatt, 1998). Social setting provides some indication of the nature of the resources available, the urgency of tasks, and the general ambiance. In response settings, normal resources may or may not be available and familiar, tasks are urgent, and the ambiance is controlled chaos. Contexts can be characterized by their (technological) austerity and their similarity to environments that are familiar to the user (Table 6).

In austere or unfamiliar environments, users are less able or willing to rely on technologies that depend on environmental resources or that they do not themselves carry with them. Unfortunately, in disaster, users tend to move about, and environments change. Thus, experienced responders often express a reluctance to depend on anything more sophisticated than pencil and paper, suggesting a final design requirement:

> **Design Requirement #5:** Response technology should aim for *graceful augmentation*, allowing the technology to be integrated in or removed from the user's activities with a minimum of disruption.

FUTURE WORK

Although the present analysis is grounded in received data, the conclusions are themselves untested, so there is no proof that satisfying the derived design requirements will result in improved technology. Direct proof is well-nigh impossible, but an interesting surrogate would be to examine whether and to what extent success or failure of existing technologies can be attributed to meeting or failing to meet the proposed requirements.

The analysis itself should be extended in several ways. Evidence from responses in regions other than North America and from international relief efforts should be considered, and analysis of other phases of disaster management conducted. Also, responses to conflict-type situations (e.g., riots or civil conflicts) exhibit characteristic differences, including significant differences in emergent behavior (Quarantelli, 1993), and are deserving of separate analysis. Finally, the characterizations of users, tasks and contexts can be developed into a more complete design theory.

CONCLUSIONS

This paper brings sociological knowledge to the study of design of response technology, using the information it offers to structure the user interface design space. Analysis of three dimensions of disaster linked to response characteristics—scale, kind and anticipability—revealed implications for design and, subsequently, domain-specific dimensions for characterizing users, tasks and contexts. It also exposed five domain-level design requirements that should be considered in both research and design efforts, regardless of whether they can be satisfied fully.

An important revelation is that the combination of user, task and context is surprisingly unpredictable, that is, that first (and even second) responders may, in fact, not be First Responders: inexperienced responders may be performing expert tasks in a familiar environment, and experienced responders may be performing unfamiliar tasks in unanticipated settings. This variability is reflected in the common intuition that uncertainty, ambiguity and change are inherent to disaster, but is not often encountered in the design of conventional productivity tools, and is thus easily overlooked. Researchers and designers may, for practical reasons, need to focus on a specific user performing a particular task in a particular context, but should be aware of the risks of doing so. This work provides a conceptual basis to help them recognize and address possible limitations of such decisions, and begins to lay a foundation for a theory of design of response technology. This will, ultimately, lead to more usable and effective response technologies.

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