Crisis Informatics: Studying Crisis in a Networked World

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Abstract. Serious crises and disasters have micro and macro social arrangements that differ from routine situations, as the field of disaster studies has described over its 100-year history. With increasingly pervasive information and communications technology (ICT) and a changing political arena where terrorism is perceived as a major threat, the attention to crisis is high. Some of these new features of social life have created real change in the sociology of disaster that we are only beginning to understand. However, much of what might seem to be new is not; rather ICT makes some behaviors more visible, in particular first response and altruistic activities. Even so, with each new crisis event, the calls for technological solutions and policy change come fast and furious, often in absence of empirical research. Our lab is establishing an area of sociologically informed research and ICT development in the area of *crisis informatics.* Here, we report on some of the challenges and findings when conducting empirical study where the subject of attention is disperse, emergent and increasingly expanding through on-line arenas. We specifically consider the challenge of studying citizen-side information generation and dissemination activities during the April 16, 2007 crisis at Virginia Tech, which we have investigated both on-site and on-line.

Sociological Study of Crisis[i]: Lessons & Challenges

The sociological study of disaster has a nearly 100-year history of investigating a wide range of social phenomenon during pre- and post-phases of natural, human-induced, and technological hazard events (Perry, 2006). Researchers adapt empirical methods—largely qualitative—to capture what are known as *perishable data* before features of the social phenomena that arise in the non-routine situations disappear. Known as *quick response research* (QRR), disaster social scientists deploy to disaster sites to conduct direct observation and face-to-face interviews, gather field documents, and capture images (see for instance, Quarantelli, 2002).

Information and communication technology (ICT) has expanded the reach of disaster sociology, which brings new challenges to its empirical study. ICT in recent disasters have served as communication platforms for disaster survivors, curious onlookers, and compassionate helpers wishing to aid those directly affected by crisis. Disaster organizations as well as individuals are able to participate in response and relief efforts without ever setting foot in the geographical space of the disaster (Palen & Liu, 2007). Sociologists have long-documented the nature of the phenomena of information and population *convergence* onto the physical sites of disasters (Fritz & Mathewson, 1957; Kendra & Wachtendorf, 2003), and we

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see parallels of such behavior on-line. In addition, we see new roles and functions emerging as people, including those in the geographical space of the disaster as well as those outside it, go on-line to provide, seek and broker information.

These changes are met by an especially high interest in crisis in today's political arena, where terrorism is presented to the public as a major threat. In the US as well as elsewhere, increasing amounts of federal spending is directed at the development of organizational processes and technology for disaster management, which is often detached from the century-long work of empirical study on the topic. Public interest is easily fueled by the emergence of "citizen journalism" as an outcome of ubiquitous computing, where people in the geographical space of the disaster can serve as eyewitnesses to ensuing events. In addition, traditional news media are now leveraging disaster-related activity on social networking sites, for example, to find people to talk to about their story leads.

Disaster researchers are beginning to recognize the importance of researching on-line activities, including Schneider and Foot's investigation of "crisis communication" information-seeking behavior after the September 11, 2001 attacks in the US (Schneider and Foot, 2004) and James and Rashed's study of Hurricane Katrina blogs (James and Rashed, 2006). However, just at a time when the interest in ICT and disasters from many sectors is at a high, disaster research activities tend to be conservative, and caution against the investigation of the virtual as a substitute for on-site investigation (Stallings, 2006): the field of disaster studies was, after all, born out of the need to empirically correct the inaccurate and sensational reporting of disaster-related behavior.

Even though much new information about any given disaster is now available through digital means, the rapid spread of information across the Internet means that, as a way to account for what happened *within* the space of the disaster, it is not necessarily reliable. This should be no surprise, but the reader can imagine how easily this might happen. However, when the goal is to explain large-scale interaction beyond the disaster space, the rapid and widespread distribution of information—independent of its accuracy—*should* then become the subject of study. As with any research, the subject of investigation guides the methods employed and sites of study. However, because of the significant shift from disaster events with inherent spatial constraints to events that now include a widespread, digitally-enabled social arena, disaster and information science researchers alike are newly struggling with how to rigorously account for social phenomena on-site as well as on-line, because those short-lived, non-routine activities are increasingly simultaneous and intertwined.

We turn now to our research of the crisis at Virginia Tech on April 16, 2007, where a single shooter killed 32 people over the course of an approximately two-and-a-half hour period in two buildings on the university campus. Our overarching objective has been to outline the extended social arena of this crisis as supported by on-line activity. More specifically, we wanted to account for and describe some of the central citizen-side information dissemination activities following the crisis, though in the immediate days after the event, we could not know how long this time period of study would need to be, nor exactly where all the sites of study might be found. We were concerned with mapping these activities—or not—back to existing empirically-understood descriptions of post-event behavior that largely predates pervasive ICT. In the next sections, we describe our methods—and then reflect on the emergence of those methods as we traced significant pieces of information and activities over time—and report on preliminary findings that were born of the *multi-sited* investigation.

Studying the Crisis at Virginia Tech

The analytical task of understanding the constantly changing social relations that accompany crisis is enormous. This study, which was the first of this scope for our research lab, required that we formulate *how* to study the crisis *as* we studied it, even when we had clear methodological starting points from the disaster studies literature at hand (Stallings, 2002). The challenge here has been knowing 'where to look.' This is not an unfamiliar experience in ethnographic work, and is in fact inherent to the process, particularly for what is known as multi-sited ethnography which "takes unexpected trajectories in tracing a cultural formation across and within multiple sites of activity" and "ethnographically constructs aspects of the [life or social] system itself through the associations and connections among sites that it posits" (Marcus, 1995). Research on crises in today's networked world—or at least for many questions one could ask about crisis—practically demands a multi-sited approach. In this case, other sites of interest are at least those that we find on-line, locales that not only extend the social reach of crisis, but whose activities often stitch seamlessly back to the activities occurring in the physical locale of crisis event.

Methodological Approach & Data Representations

Our work began within hours of the media reports of a shooting on the Virginia Tech campus, located in Blacksburg, Virginia, on Monday morning, April 16, 2007, when we began monitoring official and unofficial news releases. One of the first news releases on CNN.com mentioned students posting information from within their journalism class to a website as the crisis unfolded; this report piqued our interest about the forms of communication that might be used to support information generation, seeking, and sharing in this college-campus-situated event.

We made the decision that the methodological approach to our research questions about peer-to-peer communications in the initial hours following the shooting would require both monitoring on-line activity as well as on-site quick response research. Though we knew that we did not at all understand the full space of concerns around these communications at that time, we knew that the on-site "crisis communications" between students and others in the space of the crisis could have important relationships to what was happening on-line. We contacted faculty colleagues at Virginia Tech to assess accessibility and to generate an initial sample of interviewees. Two team members went to Blacksburg five days after the shooting (from Saturday, April 21 to Wednesday, April 25) to conduct face-to-face interviews one-on-one, in small groups and in classroom groups, and collect documents and artifacts including digital photos of public gatherings and other memorialization activities. A standing human subjects protocol pre-approved for crisis events and modified to this particular situation expedited logistics.

During this time, the campus (which closed following the shootings) had re-opened to students, and a number of memorial events took place. The team conducted a total of 56 face-to-face interviews with students, faculty, and staff from the Virginia Tech campus as well as community members in Blacksburg. Many of the interviewees were selected as a result of convenience sampling; they were in geographical proximity to one of our research team members and expressed willingness to talk about their experiences with a researcher. In addition, one researcher visited a campus sorority house with which she had connections and another researcher visited classes at the invitation of our faculty colleagues. Interview questions focused on how individuals were first made aware of the shootings, what they did once they were cognizant of the situation, and how they stayed updated throughout that first day. The sampling was such that we cannot and do not claim that it represents the whole

campus. Our analysis can only describe the actions of these people in particular, but nevertheless yields important insights about critical information paths in this event.

During this time, the rest of the research team members continued to remotely monitor newsfeeds and began to investigate, at a high-level, a number of information and digital repositories and social networking sites (including flickr, English language Wikipedia, Facebook, Myspace, orkut, Second Life). Once our team members returned from the field, we put into place a more systematic process for sampling and archiving on-line interactions that began on May 9. For example, the unwieldy Facebook had over 500 groups that included the Virginia Tech Shooting as its topic; we considered these and archived 50 of these groups based on features that seemed significant: notable membership size, exchanges that centered on people's well-being such as "I'm OK" and "Are you OK" types of messages, groups that were started on April 16 with extended activity, and groups that had notable connections to other on-line forums (petitions, for example) or to the physical space of campus (such as an existing group created for incoming Virginia Tech students). Additionally, we set criteria to exclude groups focused on memorializing; this is not because memorialization activity is not important, but rather because this activity was abundant and already happening in the groups that we had retained for further study.

The decision to archive sites on the net was iterative. As we discovered more pointers to forums, we archived them. Though we discriminated where and when we could, we archived sites even if we weren't sure if they would prove important; our reasoning was to collect this data before it disappeared. Later, a sampling of the forums we archived became the focus of more intensive ethnographic research, once we built a high-level understanding of the activities that had taken place. Our investigations and analyses continue today.

Figure 1. Data visualized by timeline on April 16, 2007.

As Marcus explains, "strategies of quite literally following connections, associations, and putative relationships are thus at the very heart of designing multi-sited ethnographic research" (1995), and describes the nature of our approach—one that involves checking interpretations against the cumulative knowledge of disaster studies to help resolve when we reached a satisfactory explanation for information traced across different people, forums and places. Figure 1 shows the central analytical workspace—a detailed timeline of the first two days of the crisis that depicts critical informational events. The total timeline stretches over about 25 feet on our lab wall. As accurately as we are able—usually down to the minute—we have populated the timeline with data that pinpoints citizen-side communications ("informal" communications) against official communications (university email, web postings, press conferences; also known as "formal" communications) from data collected across *sites of interaction*, as we began to call them.

Sites of interaction were places—be they virtual or physical—of social exchange about the disaster event.[1] Our timeline included data about information generation and seeking activities from our field work, Wikipedia's VT pages editing activity; select Facebook groups; flickr activity; and on on. This careful attention to temporal detail is essential to accounting for and interpreting information dissemination and other activities, and placing them within a context of large-scale interaction.

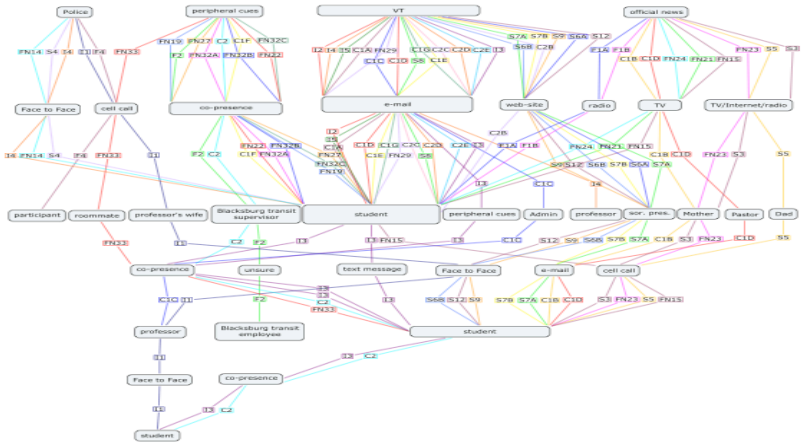

Figure 2. Data visualization of an information network analysis that is underway; when completed, it will depict how field study participants learned about the event (medium, people, and tracings between known or apparent information sources)

An Overview of Findings

We next report on a subset of findings that describe some features of the large-scale social interaction that occurred after this event over multiple sites of interaction. Though the discussion is not a complete one given the constraints and goals of this paper, we introduce descriptions of citizen-side behavior in the immediate aftermath of the Virginia Tech crisis as a cultural formation (in the words of Marcus, 1995 and peers) that was produced over multiple sites of physical and virtual interaction.

Figure 3, below, summarizes some central features of the post-crisis society, by depicting critical landmarks and trajectory activities during the first 8 hours of the event (our by-the-minute analyses continues for another 35 hours, but we focus on a narrower window here). The yellow entries mark the first and second shootings (where 2 people and 31 people died, respectively); the red entries mark some of the information-dissemination critical activities by the university; light blue entries highlight some of the first and significant peer-to-peer communications. Gray regions refer to significant activities (occurring both on-line and off-line) that have a larger set of data points than can be completely described in this diagram.

Though the crisis event, in hindsight, happened over the course of just about 2.5 hours (as marked by the first and second shootings), it wasn't until late afternoon on the first day that students were told they could safely leave their dorms. During the period between the first shooting at 7:15am (which made national news) and the second shooting at around 9:30am—*before* people realized that the second shooting happened—members of the VT campus were

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1 Defining the unit of analysis of our sites was a part of the analytical refinement in the ethnographic investigation. A virtual site is not simply "the web" or "on-line;" rather, it might, in one case, have a unit of analysis that includes the whole of the site. In another, it might be a group within a social networking site; and in still another, it might mean a thread within that group. Furthermore, whereas in the beginning of the process an entire social networking site might be a site for investigation, the research leads to, refines and constrains the scope of investigation to suitably narrow units of analysis that resolve the scope of the question at hand. This is a more powerful and useful way of thinking about social interaction versus the simply "on-line" and "off-line."

receiving and placing calls and making other forms of contact to family members off-campus. However, it wasn't until news of the second shootings became known that the information seeking activities became more pressing—for some, this was during the time of the shooting when they heard gunshots, but for those removed from the site of the crisis, this was not until around 10:16am when an email advisory to stay inside was sent. Parents in the meantime had already been speaking to their children who were on-campus, and so, in those situations, they had been essentially talking to them during the *Impact stage* (see Figure 4) and had reassurance that they were still safe in spite of mounting seriousness. Many parents, in fact, woke their children with a cell phone call; and this was the first notice of the event for many students. This set of behaviors is best described as belonging to the *Inventory stage* (Figure 4), when an individual takes stock of personal well-being, and moves to a collective inventory of what has happened.

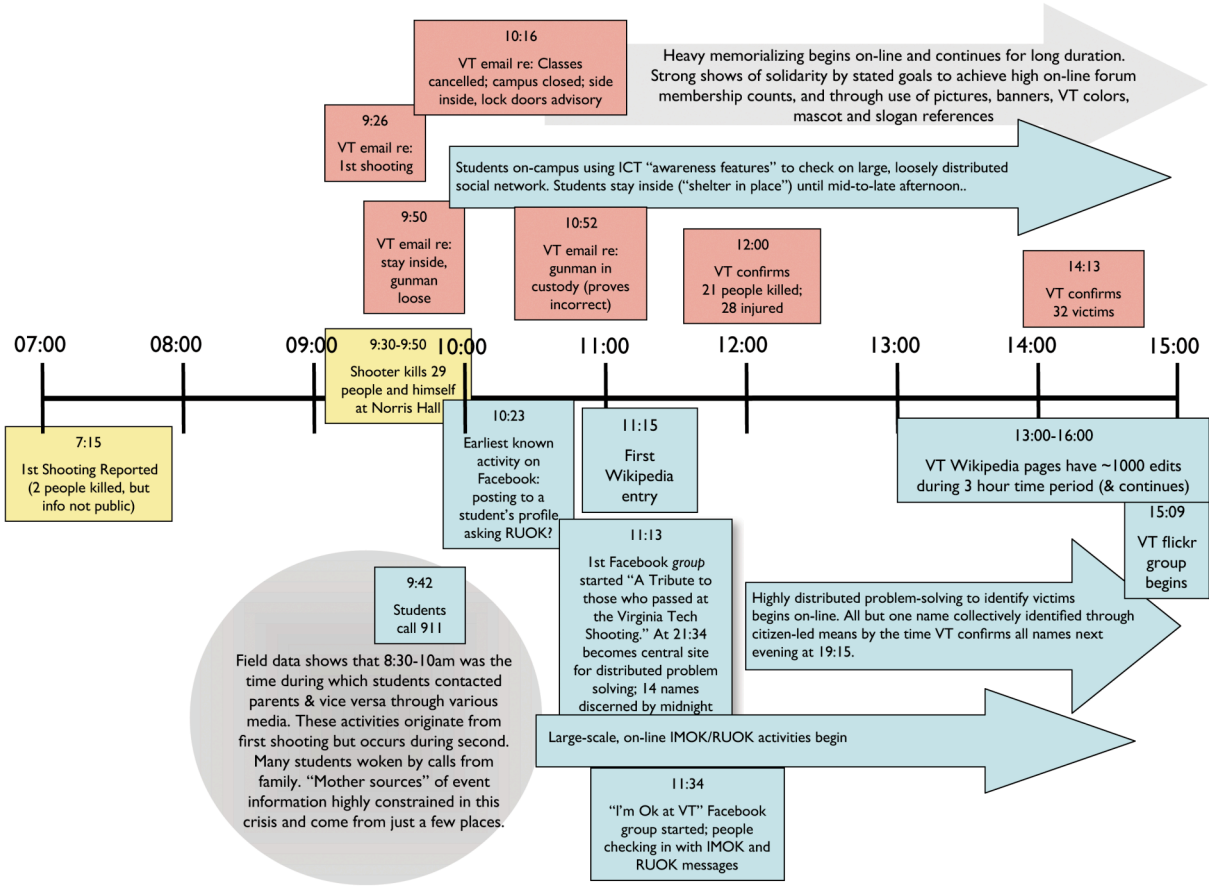

Figure 3. Timeline of selected on-line and on-site activities during first 8 hours of crisis

It was after the 10:16 am email message that the on-site digital messaging to check the welfare of fellow students began. (We note that the focus of our data collection during this phase was with the student population—many of whom were on-campus or in nearby housing—though staff and faculty were working within the same decision space.) Students were told to stay inside, and it was then that they turned to text messaging and instant messaging (IM) to check the safety of friends located elsewhere. IM provided both concurrent and passive ways of communicating and ascertaining that friends and acquaintances were okay. People could contact large numbers of people in a short time. These communications are also supported by what are called *awareness features* in ICT (for recent work, see Bardram et al, 2006), though design of such features is not always intentional, and are an

outcome of other implementation decisions. Instant messaging, by virtue of showing who is on-line and active, allows users to have co-temporal *awareness* of the presence of others. In the case of VT, if someone's IM "buddy" indicator was active, that person had to be on-line and therefore not injured. Groups on Facebook were used in the same way, except Facebook had the advantage of connecting tens of thousands of VT students. On a college campus, where students (as well as faculty and staff) have large social networks comprised of many loose ties, Facebook was a powerful virtual destination because it made it easier to detect who was safe by their on-line activity.

It was not long before these digital communications were complemented by newly spawned and more organized, explicit activities of direct inquiry and accounting. At 10:23, 7 minutes after the VT email message indicating that a very serious crisis was unfolding, a post to a VT Facebook user's profile appears asking about her welfare—the earliest Facebook activity about the tragedy that we have found. At 11:34am, an entire Facebook group designed to be a place for self-reporting of safety began, the "I'm OK at VT" group. These activities are in keeping with the Inventory phase yet, because of their distribution and digital traces that make information permanent for a time, reveal important new ICT-enabled behavioral phenomena in disaster response.

Stage 0: PRE-DISASTER State of social system preceding point of impact
Stage 1: WARNING Precautionary activity includes consultation with members of own social network
Stage 2: THREAT Perception of change of conditions that prompts survival action
Stage 3: IMPACT Stage of "holding on" where recognition shifts from individual to community affect and involvement
Stage 4: INVENTORY Individual takes stock, and begins to move into a collective inventory of what happened
Stage 5: RESCUE Spontaneous, local, unorganized extrication and first aid; some preventive measures
Stage 6: REMEDY Organized and professional relief arrive; medical care, preventive and security measures present
Stage 7: RECOVERY Individual rehabilitation and readjustment; community restoration of property; organizational preventative measures against recurrence; community evaluation

Figure 4. Eight Socio-Temporal Stages of Disaster (Powell, 1954; Dynes, 1970). Boundaries across phases are always fuzzy, and stage-related behavior can be concurrent.

During this time, activity on Wikipedia began at 11:16, within one hour of the official VT email indicating that classes on campus were cancelled. Authorship traffic on this site quickly grew throughout the day as people contributed new information, particularly the names of the deceased as they became known (reaching a high at the 15:00-16:00 hour, with a total of 1570 cumulative edits by that time). The important point is that these names were discovered *before* VT had officially announced them—this is the remaining focus of our discussion here.

The activity within Wikipedia is indicative of what was happening at large, and is an activity in disaster response that is newly enabled by pervasive and networked ICT. After the VT press conference at noon on the day of the event when they released information that at least 21 people were confirmed dead and 28 injured, we saw the launch of *large-scale problem-solving activity*. Over a set of web sites that were the focal points for this converging information, members of the international public began trying to determine who the victims of the crisis were. People reported personal information they knew themselves or had seen posted elsewhere by others. Though a subset of problem-solvers knowingly leveraged the social distribution of information, the distributed problem solving activity is best understood as being collective rather than orchestrated. We know this because lists were compiled in *different discovery orders*.

When VT confirmed that the final death toll was at 32 people plus the shooter at 14:13 this, we interpret, constrained the collective problem-solving space. Between specific Facebook groups and Wikipedia (as well as other sites and news outlets that ended up serving as feeders into those sites) the *total compiled* information across all lists was a correct identification of the 32 victims, *before* VT released names to the public. What's more, the discovery of the names was not in the same sequence across lists, nor was any list fully complete, indicating concurrent parallel problem-solving and information-gathering.

Participation in the distributed problem-solving activity included family and friends—and students on behalf of them—seeking information about their missing loved ones. As one illustration, at 17:19, 10 hours after the first shooting had occurred, a post on the "I'm OK at VT" group read: "If anyone knows anything of <name-of-victim> who was in Norris 207, please let me know."[2] In what we call a *desperate move,* people turned to on-line forums — and in this case, one designed to self-account—at a time when we speculate that most other sources had been exhausted.

Motivation for participation in the distributed problem-solving activity by other people (which were many more than those directly affected by the crisis) was driven, we propose, by the same kinds of behaviors that Powell (1954) and Dynes (1970) attribute to the stage of Remedy (see Figure 4). It is during this stage that victim-serving activities such as the arrival of organized and professional relief occur. Traditionally, Remedy, which immediately follows the Rescue phase of disaster, involves physical relief activities that respond directly to the needs of victims and survivors. Through our research, we have found that the activities occurring at this stage in the VT crisis include significant investment in information gathering, generating, and sharing through peer-to-peer and official communications—particularly by people who were remotely located away from the event, but who also wanted to provide some kind of assistance. The information they volunteered and the research assistance they offered were part of the "remedying" of the incomplete knowledge about the scope and implications of the event.

As a part of the remedy to the information dearth problem, the social arrangements of these distributed problem solving efforts had some critical features that differentiated them from rumor-mongering, a more usual way of reporting on public involvement (though certainly not always accurate). Though the few central citizen-generated victim lists were compiled in different sequences, *they were never incorrect.* Participants in the list-building activities self-policed, and they knew that adding a name to the list was a serious statement indeed. Accuracy, verification, and gravitas ruled the interaction on these focal point sites. On Wikipedia in particular, contributors participated in an editorial dialogue that critiqued accuracy of the informal, citizen-originated information and their channels of communication, and how that information should be interpreted via formal channels.

The problem-solving activity period closed when university sources released names of the deceased at 19:15 on 4/17, which confirmed the results of the collective research (a partial set was released earlier at 04:00am, but the citizen-led naming of victims still precedes this announcement). Finally and briefly, Memorialization activity occurred in parallel and long after the official names were released. A stage 7 community evaluation behavior occurring as a part of Recovery, Memorialization accounted for global participation. Notable on-line behaviors included strong shows of social solidarity through setting high digital forum membership achievement goals, and widespread use of VT school colors and symbols.

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2 Though the names of victims are publicly available, we have chosen not to list names here, as this information is not necessary to communicate findings.

Toward "Crisis Informatics"

As demonstrated in this research, the social arrangements of disaster are extending in the presence of networked, pervasive ICT, though the kinds of behaviors that we see strongly parallel those that have long been documented in empirical disaster studies. Given the gravitas of disaster events, the ubiquity of ICT, and the collective hope that ICT can in some way mitigate disasters' effects, we call for a union of research that explicitly bridges and crosses disciplines for these new and changing conditions: *crisis informatics.*

Crisis informatics (first coined by Hagar, 2007 and elaborated here) includes empirical study as well as socially and behaviorally conscious ICT development and deployment. Both research and development of ICT for crisis situations need to work from a united perspective of the information, disaster, and technical sciences. The work presented here focuses on some of the methodological challenges that empirical investigation now faces, as well as its approaches, solutions and—we hope—its rewards. Methodological issues and empirical studies are not the only components of the crisis informatics area, but they are central ones.

It is our hope that a multidisciplinary alignment in crisis research and development will guide the technologies, infrastructures, and policies we create to support the real and newly extended social arrangements of disaster. As a matter for a global society that will include "cyberinfrastructure"—the topic of this paper's venue—the progress we make on the subject of crisis informatics will inform the design of our socially connected future, where the non-routine remains inevitable.

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Notes

[i] We use the term "crisis" in our work to describe, as best as terms allow, large-scale emergency activity that includes "disasters" but also might include other kinds of events. Depending on what aspects of the event one is considering, the scale of a "crisis" as used here is closely related to that of "disaster," and, as such, means that empirical orientations, scholarly knowledge and practical knowledge from *disaster studies* are the foundations that frame our research. We note that "disaster" is not usually used to describe school shootings, which certainly does not mean that school shootings are not disastrous, only that the social arrangements around such events tend to be differently organized and driven. However, we note that much of the informal and formal response to the Virginia Tech crisis parallels what we see in disaster events, with the State of Virginia declaring a state of emergency, the nature of the widespread public response, and so on. In short, the definition of disaster is not neat (see Perry & Quarantelli, 2005), nor is any other synonymous term, but with the pervasive availability of ICT and expanding political attention to significant events (whatever those features of significance happen to be), many emergency events can become of a critical scale that is in keeping with more traditional sociological understandings of disaster.