Hastily Formed Networks

The ability to form multi-organizational networks rapidly is crucial to humanitarian aid, disaster relief, and large urgent projects. Designing and implementing the network's conversation space is the central challenge.

On Sept. 11, 2001, terrorists attacked the World Trade Center, taking 2,749 lives. The attack resulted in severe economic impact, especially to airlines, and a stock market loss of $1.2 trillion. On Dec. 26, 2004, a tsunami from a 9.1 earthquake overran the shores of many countries along the vast rim of the Indian Ocean. Over 283,000 people died. On Aug. 29, 2005, Katrina, a category-5 hurricane, knocked out electric and communication infrastructure over 90,000 square miles of Louisiana and Mississippi and displaced 1.5 million people. Six months later, New Orleans still housed fewer than 100,000 of its original 1.2 million residents. On Oct. 8, 2005, a magnitude-7.6 earthquake devastated the Kashmir region of Pakistan, killing over 87,000 people. Besides being unexpected major disasters, these events had one other common feature: they all involved hastily formed networks that quickly mobilized, organized, and coordinated massive humanitarian responses.

The severity of these disasters drove home an important point: the quality of the response depended not on response planning or on new equipment, but on the quality of the network that came together to provide relief. How quickly were voice and data communications restored? How well did the many players from disparate organizations collaborate? How effectively did the network deliver help to the victims? These incidents demonstrated sharp differences in the quality of the hastily formed network (HFN), which directly affected the effectiveness of the response. Noting that these networks almost always involve military, civilian government, and non-government organizations, the U.S. Departments of Defense and Homeland Security have

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made it a priority to learn how to effectively assemble HFNs. We coined the term at the Naval Postgraduate School in 2004.

The lessons learned from the networks involving government carry directly into private settings. They will benefit any urgent network of multiple organizations with no common authority that must cooperate and collaborate.

Hastily formed networks is an area where advanced networking technology and human organization issues meet. They can work well together, or they can clash. Our purpose here is to give an overview of this critical area and the challenges it offers to computing professionals.

ORIGINS

The idea of quickly forming a team for a particular, urgent task, and then disbanding it when done, is not new. Table 1 lists three categories of events for which an HFN must respond. Because it involves relatively small teams and known networks, the first category is the easiest and least likely to stress the HFN.

The middle category is the type that emergency agencies such as police and fire departments prepare for. They have professional, highly trained teams ready to respond to particular incidents. They have well-developed practices for advance planning, training in appropriate skills, and positioning of equipment. They already use terms like "ad hoc network" and "crisis response network" to describe what they do.

Category	Characteristics	Examples
K: Known	Know what to do Use existing network structures May choose not to respond	Fast response team for time-critical business problem or opportunity
KU: Known Unknown	Know what to do Don't know time or place Responding network structure known	Local fire, small earthquake, civil unrest, military campaigns
UU: Unknown Unknown	Don't know what to do Don't know time or place Responding network structure unknown	9/11 attack, other terrorist attacks, large earthquake, major natural disasters (Note: KU events can become UU events when scaled up to large areas or populations)

Table 1. Kinds of events requiring response from hastily formed networks.

The third category puts the greatest stress on the HFN. These events require response beyond the control and capabilities of any single agency. The network structure will depend on the event and the responding organizations.

The main aspects of the third-category challenge are:

• **Genuine surprise.** The precipitating event is in no known category. There has been no advance planning, training, or positioning of equipment.
• **Chaos.** Everyone is overwhelmed. No one understands the situation or knows what to do. People are frantic and panicky.
• **Totally insufficient resources.** Available resources and training are overwhelmed by the magnitude of the event.
• **Multi-agency response.** Several agencies must cooperate in the response, including military, civilian government, and private organizations. These groups have had little or no prior reason to collaborate. The shock of moving from a state of "coexistence" to a state of "collaboration" can be overwhelming.
• **Distributed response.** The response is distributed over a geographical area into many local jurisdictions. The authority to allocate resources and reach decisions is distributed among many organizations. Decisions by command-and-control do not work.
• **Lack of infrastructure.** Critical infrastructures such as communications, electricity, and water do not work. Makeshift infrastructures must be deployed quickly.

HFN DEFINED

The first priority after the precipitating event is for the responders to communicate. They want to pool their knowledge and interpretations of the situation, understand what resources are available, assess options, plan responses, decide, commit, act, and coordinate. Without communication, none of these things happens: the responders cannot respond. Thus the heart of the network is the communication system they use and the ways they interact within it. We call this the "conversation space" of the HFN.

An HFN has five elements: it is (1) a network of people established rapidly (2) from different communities, (3) working together in a

shared conversation space (4) in which they plan, commit to, and execute actions, to (5) fulfill a large, urgent mission.

An HFN is thus much more than a set of organizations using advanced networking technology. To be effective in action, HFN participants must be skilled at:

• Setting up mobile communication and sensor systems;
• Conducting interagency operations, sometimes called "civil-military boundary";
• Collaborating on action plans and coordinating their execution,
• Improvising; and
• Leading a social network, where communication and decision making are decentralized, and there is no hierarchical chain of command or ex officio leader.

Most participants do not have a need for these skills in their individual organizations. When they come together, therefore, they find it difficult to accomplish these tasks. When combined with the overwhelming nature of the urgent event, these inherent difficulties can lead to a breakdown in the conversation space.

CONVERSATION SPACE

The ongoing need to communicate and coordinate is fundamental for the success of any HFN. The term conversation space was introduced for the medium in which all this takes place—from forming community responses to delivering actions. The conversation space is (1) a medium of communication among (2) a set of players (3) who have agreed on a set of interaction rules. These three aspects are summarized in Table 2.

One of our early conclusions was that the effectiveness of the HFN rests on the quality of the conversation space established at the outset. It is not a foregone conclusion that an effective HFN can be established even when the players are trained professionals, as the situations in New York City after 9/11 and in New Orleans after Hurricane Katrina illustrate. In New York, the mayor understood intuitively that success would depend on everyone, including especially the residents of the city, feeling included in the relief effort. He made sure information was shared, even if piecemeal. While there were some initial coordination difficulties, the network came together and was effective in relief and recovery. A different picture occurred in New Orleans. The various agencies had major difficulties in coordinating and the Federal Emergency Relief Agency (FEMA) did not deliver what people thought it had promised. At all levels there was a lot of finger-pointing and wrangling over who would do what and who would pay for what. When the president put a new man in charge at FEMA, there was no immediate improvement in effectiveness or criticism of the agency. Attempts to impose standard military-style command-and-control in Louisiana and Mississippi were ineffective. This is not intended as a criticism of New York, Louisiana, or Mississippi officials, but rather an illustration that effective coordination may not happen even when all the parties want it to happen.

Certainly a major difference between New York and New Orleans was the sheer scale of the event. New York lost infrastructure in a limited area of perhaps 100 square blocks. The primary agencies in the network ultimately reported to the mayor. Police and fire radios provided basic communications in the "ground zero" area. In contrast,

Table 2. Components of conversation space.

Category	Characteristics	Examples
Physical systems	Media and mechanisms by which people communicate, share information, and allocate resources	Telephone, power, roads, meeting places, supplies, distribution systems
Players	Players included and their roles, core competencies, and authorities	Citizens, fire department, policy department, highways department, federal emergency management agency
Interaction practices	Rules of the "game" followed by the players to organize their cooperation and achieve their outcomes	Situational awareness, sharing information, planning, reaching decisions, coordination, unified command and control, authority, public relations. (Note: environment has no common authorities, no hierarchy, many autonomous agents, decentralized communications)

New Orleans lost an entire city and was part of a large area (90,000 square miles) with severely damaged infrastructure. All communication systems were knocked out; and as they were gradually being restored, the limited-bandwidth channels were overwhelmed by sheer numbers of citizens trying to use them. Many more agencies had to cooperate on the response. Coping with all this effectively was completely outside most responders' experience.

New York City quickly built trust among the responders and citizens. New Orleans experienced considerable difficulty in building trust.

But this is one of the lessons: the more overwhelming the event, the more likely turf-asserting tendencies will occur and interfere with the effectiveness of the network.

The overarching lesson is: the effectiveness of an HFN depends as much on the participating people and organizations as it does on the communication system through which they interact.

CONDITIONED TENDENCIES

It is well known that individuals under severe stress often forget their recent training and regress to old, ingrained habits [1, 7]. Richard Strozzi Heckler calls these old habits conditioned tendencies [6]. The old habit is likely to be inappropriate for the current situation and to make matters worse.

The National Institute of Standards and Technology ([4], p. 174) concluded that "a preponderance of evidence indicates that emergency responder lives were likely lost at the World Trade Center resulting from the lack of timely information-sharing…" Police radio transcripts cited by NIST indicate that NYPD helicopters monitoring the two burning towers detected signs of structural collapse in the North Tower and issued an emergency evacuation order to all police. Yet no one in the police department communicated the imminent-collapse information to the fire department. What accounts for this bizarre behavior?

Joseph Pfeifer, a deputy assistant chief in the New York City Fire Department, gives in his master's thesis a detailed example of conditioned tendencies instilled by emergency-response organizations, which paradoxically can render them incapable of effective response in an emergency [5]. Pfeifer was among those responding to the 9/11 disaster in the World Trade Center. His explanation for non-communicative behavior was that organizational biases—ingrained social habits of the separate organizations—prevented emergency personnel from talking to one another. One of these biases is organizational social identity that prefers to share information within the group but not outside. Under stress, the group members do not think to collaborate or share information outside the group, or to take personal responsibility for the welfare of members of other groups.

The purpose of Pfeifer's study was not to assign blame for needless loss of life in the 9/11 attacks, but to recognize the organizational conditioned tendency as a real phenomenon that can disable an HFN. The question is how to prepare organizations to work together in an HFN and avoid the conditioned tendency. Pfeifer proposed that the agencies use unified command networks, in which leadership is shared among different organizations; for example, an executive committee. This practice will likely create the foundation for HFNs that do not suffer non-communication leadership paralysis.

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A Guide to Effective HFNs

(1) The quality of the conversation space is critical to success. The space includes the communication systems, the participants, and their interactions within these systems. Effectiveness in conversation space rests on skills that participants may not ordinarily learn in their separate organizations.

(2) The physical communication systems are part of conversation space. Plan and test mobile technologies that can be set up quickly when the regular infrastructure is down. Arrange for security forces to protect the temporary infrastructure. Use and test all communications equipment regularly. Use standard software and protocols—interoperability and simplicity of interconnection will be important. Web services are a good example.

(3) The participating organizations are another part of conversation space. Each brings its own culture, standard practices, and decision-making protocols—which may be incompatible with other organizations. Individuals can become disoriented when familiar organizational practices are suspended. They fail to take initiative, while waiting for orders that will never come. They do not know how to function when there is no common authority, their established command-and-control practices do not work, and collaboration, not control, is the only way to get actions done.

(4) Information glut will be a problem in the network. As com-munications are initially restored, the victims will overload the severely limited bandwidth as they try to communicate with their families. The responders themselves will overwhelm their colleagues with situational reports and other data. New technologies will be needed to manage information glut and keep the network functioning.

(5) Understand and practice the effective technologies for collaborative networks. These include Web servers to distribute information, wiki and discussion-thread software, chat and instant-messaging services, virtual markets, and coordination services such as Groove (but Groove is restricted to Windows platforms).

(6) Prepare to overcome the barriers to interorganizational collaboration. These include conflicting missions, unclear roles, turf protection, incompatible processes and information systems, disparate cultures, accountability, mistrust, and lack of knowledge of others' capabilities [3].

(7) Prepare for organizational conditioned tendencies to appear under overwhelming stress. Train group members in the basic HFN skills. Promote political support for the organizations to cooperate, mutual respect for the competencies that each organization brings, concern for each other's welfare, and personal responsibility for actions and outcomes. Practice with "unified command"—an executive committee representing the participating organizations that respects the core competencies that each organization brings.

(8) Train the skill of improvisation. This is a challenge for normal rule-oriented agencies.

Challenges for Computing Professionals

HFNs bring new words and concepts such as conversation space, coordination without hierarchy, and conditioned tendency. Learn these concepts; they are important.

Interoperability and simplicity are key technical challenges for HFNs. Services offered via Web interfaces are highly interoperable; anyone can use them from any computer. Chat and text messaging services are highly interoperable. But many key services are not. For example, many responders have found the Groove software to be useful for coordination, but Groove runs only on Windows computers; responders with Sun workstations, Apple Macintoshes, or Linux-based computers are out of luck. Many wireless networks are not fully interoperable, for example, Linux and Apple machines use different protocols from Windows machines for encryption and passwords.

To prevent information glut, we need tools to model, label, and filter information so that network participants receive the information most likely to be valuable to them. In crises especially, the participants need to make most effective use of the limited resources of decision-making time and communica-

tions bandwidth by restricting the flow of unimportant bits. Hayes-Roth shows how a 100,000-fold drop in information volume is easily achievable without loss of effectiveness [2].

Learn about the organizational issues, such as collaborative cooperation and managing conditioned tendencies. You may be part of an organization that responds in an HFN, and you will need to know this.

Understanding how to create HFNs is one of the most challenging parts of modern networking. It is about how a network, its people and its equipment, may function efficiently under extreme stress. **C**

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