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Interorganizational Coordination in Dynamic Context: Networks in Emergency Response Management[1]

Naim Kapucu, Ph.D.[2]
Department of Public Administration, University of Central Florida

This paper addresses the inter-organizational network in response to an extreme event. Specifically, this paper analyzes interactions among public, private, and nonprofit organizations that evolved in response to the September 11, 2001 terrorist attacks. The research uses a theoretical framework primarily drawn from dynamic network theory and complex adaptive systems theory. The study assumes that the increased efficiency that would likely accrue in mitigation and response to disaster if agencies learned to collaborate more productively. Organizational analysis techniques were used to identify the major organizations that participated in the response system. The research found that effective response and recovery require well-coordinated interorganizational networks and trust between government agencies at all levels and between the public and private sectors.

INTRODUCTION

Public management increasingly takes place in settings of networked actors who necessarily rely on each other. Building networks of effective action is particularly difficult in dynamic environments. Yet, current administrative theorists devote relatively little attention to acting effectively in such situations. The September 11 attacks and their aftermath, along with other major disaster events, revealed much about institutional responses and collective behavior in extreme disaster conditions, underscoring what is already known about the social processes that characterize such events, while at the same time highlighting aspects of disasters that the literature has yet to explore fully.

In drawing lessons from the World Trade Center terrorist attacks in New York City, while the response activities undertaken by official emergency agencies were crucial, those activities constituted only part of the picture. Equally significant was the manner in which those agencies interacted with

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and obtained support from non-crisis organizations. It has long been recognized that disasters represent occasions in which the boundaries between organizational and collective behavior are blurred (Comfort, 1999). This paper discuses how to identify sets of structurally key players, particularly in the context of networks of organizations in response to September 11, 2001. Specifically, this paper examines the interactions among organizations that evolved in response to the September 11, 2001 terrorist attacks on World Trade Center (WTC) in New York City.

The paper addresses the following questions: How did interorganizational coordination among the organizations evolved in response to the extreme event? What primary organizations were involved in response to the attack? What were the primary nodes of interaction among the organizations in their response to the attack? This study assumes that extreme events will lead to greater density of communication among organizations and less centralized networks. As organizations increase their interactions, they share resources and information. As organizations from different sectors shares information and resources, victims in impacted areas will be served better as a result of this collaboration.

METHODOLOGY

The case study and descriptive research methods were used in conducting this research (Yin, 1994). The case study uses the data from the situation reports from the Federal Emergency Management Agency (FEMA) and interviews with selected public and nonprofit managers involved in response to September 11. Data collected through FEMA situation reports and interviews were used to develop a list of organizations that participated in response operations performed by public, nonprofit, and private organizations. Situation reports prepared by the Federal Emergency Management Agency (FEMA, 2001) were used as the official account of organizational operations following the September 11 attacks. This analysis illustrates patterns of communication and information flows among actors. The actual pattern of interaction reported by the organizations is compared with the designated responsibilities of the public organizations under the Federal Response Plan (FEMA, 1999). This comparison illustrates the differences between actual performance and designated roles in the Federal Response Plan.

I identified all the organizations that participated regardless of any interaction from the FEMA situation reports. Then, for the network analysis purposes, I identified only the reciprocal organizational interactions. With these interacting organizations I constructed the matrix for network analysis. I also reduced the number of organizations by aggregation to construct a manageable network matrix. The goal was to choose a level of "granularity" that corresponds to the problem at hand. As in a traditional sociogram, one can aggregate constituents into larger units, if that proven useful (Pentland, 1999). Second, based on identified actors from the content analysis of the FEMA situation reports, I used the stratified random sampling method to construct a sample of organizations that were actively involved in the response system. Third, semi-structured interviews (43) with the staff, managers, and director of the participant organizations were conducted. Interviews helped to clarify and expand some of the issues already discovered in the content analyses with regard to interorganizational networks in response to the attack. The network data collected from my interviews and the FEMA situation reports were analyzed using the UCINET 6.0 social network analysis program.

In the network analysis, we are always interested in how an actor is embedded within a structure and how the structure emerges from the micro-relations between individual parts. The other important factor for the design of network data has to do with what ties or relations are to be measured for the selected nodes (Scott, 2000). The other fundamental properties of a social network have to do with how connected the actors are to one another. Networks that have few or weak connections, or where

some actors are connected only by pathways of great length may display slow response to stimuli. Networks that have more and stronger connections with shorter paths among actors may be more robust and more able to respond quickly and effectively. Measuring the number and lengths of pathways among the actors in a network allow us to index these important tendencies of whole network (Hanneman, 2001; Wasserman and Faust, 1994). Indeed, most of the basic measures of networks, measures of centrality, and measures of network groupings and substructures are based on looking at the numbers and lengths of pathways among actors are used for the analysis of the collected data. This paper uses the standard network centrality measures of degree, closeness, betweenness and flow betweenness applied to groups and classes (Everett & Borgatti, 1999). Beside the group centrality, I also measured cliques, subgroups, similarity and structural equivalence.

THEORETICAL BACKGROUND: INTERORGANIZATIONAL NETWORKS

The research uses a theoretical framework primarily drawn from dynamic network theory and complex adaptive systems theory (Scott, 2000; Axelrod and Cohen, 1999; Comfort, 1999; Carley, 1999; Holland, 1995; Wasserman and Faust, 1994; Alter & Hage, 1993; Nohria & Eccless, 1992). In complex and turbulent environments, organizations frequently develop formal or informal relationships in order to work together to pursue shared goals, address common concerns, and/or attain mutually beneficial ends. In recent years, such interorganizational collaboration has become a prominent aspect of the functioning of many different types of organizations. The number and significance of collaborative forms of organizing, including interorganizational teams, partnerships, alliances, and networks, have increased tremendously. The value of effective collaborative relationships as well as the complexities and challenges they present have been recognized by many researchers, and they continue to be a frequent subject of scholarly and practitioner-oriented literature (e.g., Linden, 2002; Powell, 1990; Gray, 1989).

Many researchers have noted that network organizations reflect a qualitatively different form of governance structure than the bureaucratic hierarchies they are beginning to replace (O'Toole, 1997; Powell, 1990). In such a environment, understanding the dynamics of the interorganizational networks and the patterns of interaction have become urgent matters both for policy makers and those who seek to understand the policy making process and implementation (Gidron et al, 1992).

In this paper, the term network is used to describe multiple-organizational relations involving multiple nodes of interactions. A network is group of individuals or organizations who, on a voluntary basis, exchange information and undertake joint activities and who organize themselves in such a way that their individual autonomy remains intact. In this definition important points are that the relationship must be voluntary, that these are mutual or reciprocal activities, and that belonging to the network does not affect autonomy and independence of the members.

A large body of theory and research about inter-organizational networks now exists to explain how these relationships emerge, sustain, and create value for the whole society. A particularly interesting generic type of network involves complex production relationships that benefit from being able to form and dissolve quickly. The participants therefore wish to protect themselves against opportunistic exploitation by their partners without having to suffer the delays and costs of formal contracting. This means that there is some element of trust in the relationship so that post-transaction adjustments to meet the parties' needs and interests can be quickly addressed with minimal inter-personal and inter-organizational resistance (Bardach, 1998).

Public administration scholar Harland Cleveland predicted in 1972 that organizations are moving toward a more horizontal style of management in which leadership is shared and decisions are often

made on the basis of expertise rather than positions. "The organizations that get things done will no longer be hierarchical pyramids … they will be systems – interlaced webs of tension in control is loose, power diffused (Cleveland, 1972, p. 13).

Ackoff (1974) points out that many important current problems are "messes" that actually involve sets of interconnected problems. The multifaceted nature of these complex problems makes them extremely difficult to conceptualize and analyze and thus immune to simple solutions (Chisholm, 1998). This interdependence and complexity often require extensive collaboration among different types and various levels of organizations. Forming and developing inter-organizational networks represents a response to this interdependence complexity.

Brinton Milward (1996) uses the "hollow state" to characterize what he regards as the increasingly networked character of public management. Despite the evidence that networks are very important for public administration, much of the discussion of this subject has been vague (Wamsley et al., 1990; Provan and Milward, 2001). Helpful starts have been made in other fields. In particular, sociologists and public choice specialists have developed rich conceptualizations regarding networks (Miller, 1994; Cook and Whitmeyer, 1992; Ostrom, 1990). Public, nonprofit, and private sector resources may blend in a variety of ways. These formats permit the mutual leveraging of resources and the blending of public, nonprofit, and private attributes in ways that might not be possible in more traditional structural arrangements. This governance perspective is connected to the concern about social capital and the social underpinnings necessary to effective collaboration.

Networks in the field of public administration and organization theory are primarily based on the organizations with clearly defined boundaries (Milward, 1996; Chisholm, 1998; Alter and Hage, 1993). The effect of relations in organizations with permeable boundaries may be different. Modern organizational environments are becoming more complex at an increasing rate (Weick, 2001; Emery and Trist, 1965; quoted in Scott, 2001; Kauffman, 1993), largely through technical change (Simon, 1996). This means that uncertainty also increases, and the ratio of externally to internally induced changes also is increasing. There are instances where changing governance structures and technical changes may actually reduce uncertainty (Comfort, 1999; Weick, 2001). The interactions of organizations in a large system can generate greater complexity then the organizations themselves. Moreover, organizations tend to move toward higher levels of complexity, largely through networks. Organizations must balance differentiation and coordination to successfully adapt to the rising environmental complexity. Organizations also must determine the scope of their activities and degree of vertical integration decisions. Depending on one's theoretical perspective, these balancing conflicts are either seen as inefficiencies (rational system) or necessary parts of the negotiation process (natural system) (Scott, 2001).

Social network analysis is a well-developed and fast-growing area of organizational sociology, and it provides tools and concepts for analyzing organizations as networks (Wasserman and Faust, 1994). A meta-matrix, developed by Kathleen Carley (2002), represents a network of interactions that can be analyzed using the same graph-theoretic techniques that have been applied to networks of individuals and other entities. Meta-matrix analysis is a useful method in analyzing the structure of interorganizational response.

INTERORGANIZATIONAL NETWORKS IN EXTREME EVENTS

The dynamics of learning and adaptation, central to the complexities of an ecological system, are increasingly used as an analogy to the collaborative relations between sectors in network based systems of governance. Resilient social systems are characterized by reduced failure, measured in terms of lives

lost, damage, and negative social and economic impacts, and reduced time to recovery – that is, more rapid restoration of the social systems and institutions to their normal, pre-disaster levels of functioning. Aaron Wildawsky (1971, p. 77) describes resilience as "the capacity to cope with unexpected dangers after they have become manifest, learning to bounce back." The Resilience Multidisciplinary Center for Earthquake Engineering Research (MCEER) has identified four general properties that can be applied to all systems and to the elements that comprise systems: robustness (ability to withstand the forces generated by a hazard agent without loss or significant deterioration of function; resourcefulness (capacity to apply material, informational, and human resources to remedy disruptions when they occur); redundancy (the extent to which elements, systems, or other units of analysis exist that are capable of satisfying the performance requirements of a social unit in the event of loss or disruption that threaten functionality); and rapidity (the ability to contain loses and restore system or other units in a timely manner). Organizations can contribute to resilience in a society by incorporation other emergency response organizations and by integrating volunteers into emergency operations as appropriate.

Meta Matrix	***People / Agents***	***Knowledge***	***Resources***	***Tasks***	***Organizations***
People / Agents Relations	**Interaction Network** *Who knows whom* **Structure**	**Knowledge Network** *Who knows what* **Culture**	**Capabilities Network** *Who has what resource* **Capital**	**Assignment Network** *Who does what* **Jobs**	**Work Network** *Who works where* **Demography**
Knowledge Relation		**Information Network** *What informs what* **Data**	**Skills Network** *What knowledge is needed to use what resource* **Technology**	**Needs Network** *What is needed to do that task* **Needs**	**Competency Network** *What knowledge is where* **Culture**
Resources Relation			**Substitution Network** *What resources can be substituted for which*	**Requirements Network** *What resources are needed to do that task* **Needs**	**Capital Network** *What resources are where* **Resources**
Tasks Relation				**Precedence Network** *Which task must be done before which* **Operations**	**Sectoral Network** *What tasks are done where* **Niche**
Organizations Relation					**Inter-Organizational Network** *Which organization works with witch* **Partnerships**

Source: Adapted from Kateen M. Carley 2002.

Figure 1. Meta Matrix

Extreme events are occurrences that are notable, rare, unique, and profound, in terms of their impacts, effects, or outcomes. When extreme events occur at the interface between natural, social and human systems, they are often called "disasters" (Red Cross, 2001). Quarantelli and Dynes (1977)

define disaster as the disruption to society after the "event." Everybody is affected in extreme events and individuals and single organizations cannot prevent the harm caused by the event. In extreme events standard procedures cannot be followed and they require dynamic system to adapt to unanticipated and rapidly changing conditions. The September 11 2001 terrorist attack is an example of an extreme event with significant impact upon humanity. Extreme events trigger greater density of communication and interaction among organizations that stimulates collective action. A critical aspect of this process is the formation of new and or stronger networks among multi-sector organizations.

1. Interorganizational networks in emergencies can play an important role in facilitating the flow of information across organizational boundaries. Following are the principal pathways through which social networks enhance performance of organizational networks:
2. Social networks increase interaction among organizations that can lead to development of trust which reduce transaction costs (Coleman, 1990),
3. Social networks spread risk by providing individual members with sources of support during times of trouble, and allow the group as a whole to engage in overall higher levels of risk-taking (Fukuyama, 1995),
4. Social networks facilitate the rapid dissemination of information among members and reduce the asymmetries of information that can otherwise discourage profitable transactions,
5. Social capital improves access to resources among network members,
6. Social networks allow members to solve collective action problems more easily with less fear of defection and free riding (Ostrom, 1990)

The capacity of a society to understand and manage extreme events depends on its ability to understand, anticipate, prepare for, and respond to them (Comfort, 1999). Moreover, increasing organizational and technological interconnectedness may create more possibilities of multiorganizational partnerships for the surge of an extreme event. The WTC disaster illustrates how in disaster settings high levels of cooperation and collaboration among organizational and community actors can co-exist. Communities responding to disasters are seen as coping collectively with shared pain, loss, and disruption and as temporarily suspending ongoing conflicts and disagreements in the interest of meeting urgent needs and beginning the recovery process. Trustworthiness and social capital can, especially, play an important role in extreme events within which there is no clear policy or guidelines available to the participant organizations and individuals (Axelrod and Cohen, 1999).

INTERORGANIZATIONAL COORDINATION

Under the Federal Response Plan (FEMA, 1999), eight federal agencies in addition to FEMA play lead roles in disaster operations, with 25 federal agencies assigned responsibilities under twelve specified emergency support functions. The lead agencies include the Departments of Transportation (DOT), National Communications Service (NCS), Defense (DOD), Agriculture (USDA), Health and Human Services (HHS), Housing and Urban Development (HUD), Environmental Protection Agency (EPA), and the General Accounting Office (GAO). Two departments have dual emergency support functions. The USDA has the primary support function for firefighting, carried out by its sub-unit, the U.S. Forest Service (USFS), as well as for food. FEMA is responsible for information management, as well as urban-search-and-rescue operations. The American Red Cross (ARC) is designated as the lead agency for mass care (Figure 2).

Immediately after the attack, an intensive coordinated effort was begun by federal, state, and city government, along with volunteer agencies, in the search, rescue, recovery, and identification of the victims. Extensive assistance was directed toward the needs of victims and their families. While the physical damage was concentrated in a relatively small area, the economic and social effects were pervasive citywide. The pervasive threat of the attack created a situation of shared risk, that is, the risk of the attack is shared by all members of society. This condition of shared risk offers an important alternative perspective on response operations for extreme events. As the risk is shared, so is the responsibility for assessing and responding to that threat (Comfort, 1999). Recognition of shared responsibility immediately broadens the task of confronting the threat with organizations outside the public sector. Individuals, private and nonprofit organizations become resources for this collective response operation (Kapucu & Comfort, 2002).

Coordinating the activities of non-crisis organizations is a complex and difficult task. Public managers are reluctant to rely upon nonprofit voluntary organizations during extreme events. "Because they distrust the intentions of the volunteers, lack confidence in the volunteers skills and resources, fear that volunteer may endanger themselves or others, are concerned that volunteer may get into way of professional responders, and fear that there may be legal liability for volunteers' actions" (Waugh, 2000; p. 47). As noted in Waugh (2000) that emergency management is the quintessential government role. FEMA is the lead federal agency for responding to disasters and may link with nonprofit organizations. According to FEMA regulations, in the event of a residentially declared disaster or emergency, such as 9/11, FEMA is required to coordinate relief and assistance activities of federal, state, and local governments; the American Red Cross; the Salvation Army; as well as other voluntary relief organizations that agree to operate under FEMA's direction. Disaster response and recovery roles cross-cut 28 Federal agencies and the Red Cross, which participates with FEMA in disaster operations guided by the Federal Response Plan (1999).

PATTERNS OF INTERORGANIZATIONAL NETWORKS

In this section of the paper, I measure degree, closeness, betweenness, and flow betweenness centrality and clique and sub-groups (n-clique, c-clans, k-plexes). There are many measures of actor position and overall network structure that are based on whether there are pathways between actors, the length of the shortest pathway between two actors, and the numbers of pathways between actors. I employed UCINET (Version 6.0) for the network analysis of the data. UCINET is a comprehensive program for the analysis of social networks and other proximity data. The program contains several network analytic routines and general statistical and multivariate analysis tools.

Size of the network is critical to the structure of organizational interactions because of the limited resources and capacities that each organization has for building and maintaining networks. Usually, the size of a network is indexed simply by counting the number of nodes. In any network there are (k * k-1) unique ordered pairs of actors, where k is the number of actors. It follows from this that the range of logically possible social structures increases (complexity) exponentially with size. If the size of the network increases, the complexity of the relationships also increases.

The graph from the Federal Response Plan (FRP) is represented in Figure 2 below. We can perceive a number of things in simply looking at the graph. There are a limited number of actors (28), and all of them are connected very well in a very orderly manner as we would not expect from any complex organizational networks. There appear to be some differences among the actors in how connected they are (compare actors HUD and USDA, for example). If we look closely, we can see that some actor's connections are likely to be reciprocated (that is, if A shares information with B, B also shares information with A) but some other actors are more likely to be senders than receivers of information.

As a result of the variation in how connected organizations are, and whether the ties are reciprocated, some actors may be at quite some "distance" from other actors. There appear to be groups of actors who differ in this regard. For example, FEMA, HHS, USDA, ARC, and DOT that seem to be in the center of the action while HUD, DOC, and TVA, seem to be more peripheral.

The graph from the FEMA situation reports is presented in Figure 3 below. We perceive a number of things by simply looking at the graph as well. There are a limited number of actors here (41), and all of them are "connected." But, clearly not every possible connection is present, and there are "structural holes." There appear to be some differences among the actors in how connected they are as usual. If we compare FEMA and NYCEMO with HUD and GSA for example, we can easily see the difference. FEMA and NYCEMO are in the center of the activities. On the other hand, HUD and GSA are not very central or well connected to other organizations. If we look closely, we can see that some actor's connections are likely to be reciprocated in this network but some others are not. FEMA, NYCEMO, NYC government and mayor, and HHS seem to be in the center of the action; HUD, DOJ, OSHA, FAA seem to be more peripheral in the network.

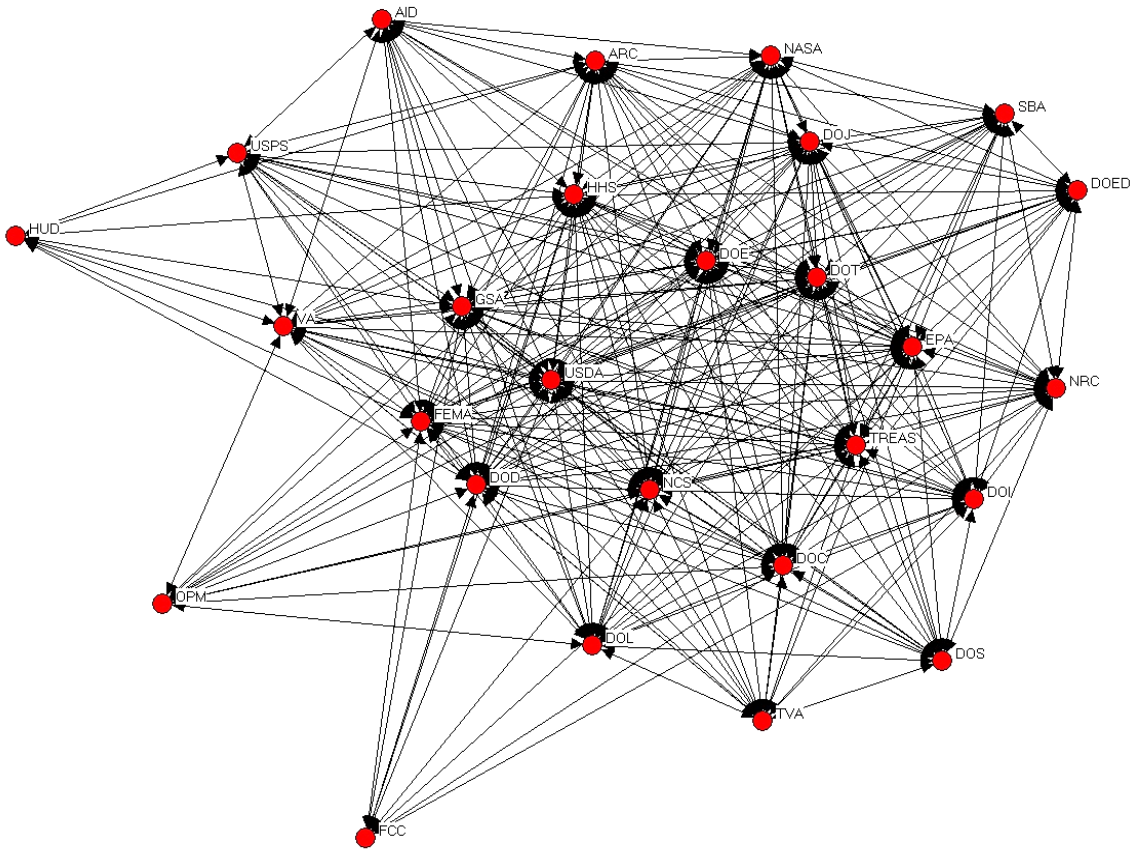

Figure 2. Networks in FEMA Emergency Response Plan

Findings from content analysis of the FEMA situation reports indicate that interactions were limited and occurred primarily between organizations of similar types. For example, public organizations tended to interact most frequently with other public organizations from the same jurisdiction; private organizations with other private organizations; nonprofit organizations with other nonprofit organizations. Interactions were infrequently reported across jurisdictional lines.

Group Centrality: Major Players

With larger populations or more connections, however, graphs may not be very helpful. Looking at a graph can give a good intuitive sense of what is going on, but our descriptions of what we see are imprecise. To get more precise, and to use computers to apply algorithms to calculate mathematical measures of graph properties, it is necessary to work with the adjacency matrix and more complicated calculations instead of the graph.

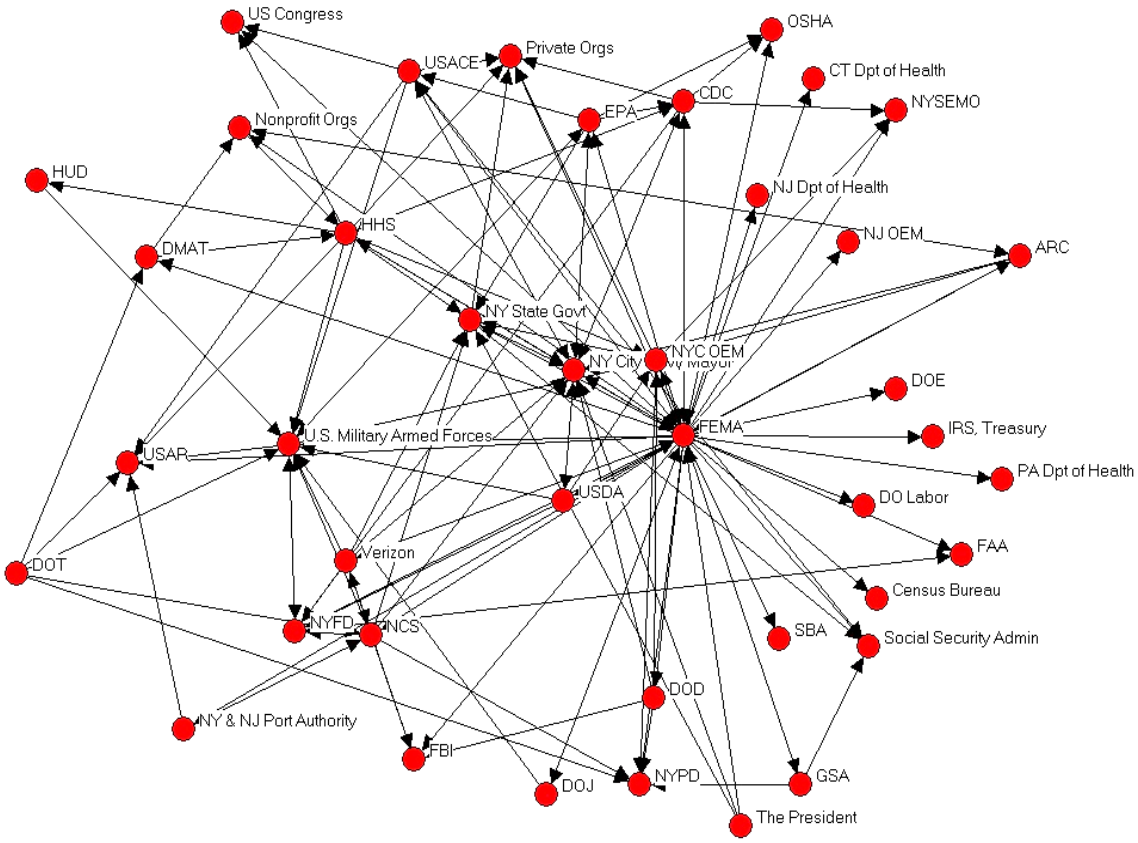

Figure 3. Organizational Network -FEMA Situation reports

One of the methods used to understand networks and their participants is to evaluate the location of actors in the network. Measuring the network location is finding the centrality of an actor. These measures help determine the importance of a node in the network. I use centrality measures as a basic tool for identifying key organizations in the response system network (Everett & Borgatti, 1999). The centrality approaches (degree, closeness, and betweenness) describe the locations of individual organization in terms of how close they are to the center of the action in a network.

Group degree centrality is defined as the number of non-group nodes that are connected to group members (Everett & Borgatti, 1999). Actors who have more ties to other actors may have access to, and be able to call on, more of the resources of the network as a whole. UCINET is used to do the counting, and some additional calculations and standardizations that were suggested by Linton Freeman (1979).

Table 1. Freeman's Degree Centrality Measures

		Degree	NrmDegree
2	FEMA	329.000	822.500
34	NY City Govt/ Mayor	87.000	217.500
41	Nonprofit Orgs	58.000	145.000
13	U.S. Military Armed Forces	42.000	105.000
27	NY State Govt	42.000	105.000
35	NYC OEM	32.000	80.000
39	Private Orgs	32.000	80.000
3	HHS	28.000	70.000
24	US Congress	22.000	55.000
10	USACE	21.000	52.500

Freeman's degree centrality measures show that FEMA (actor #2) and New York City Government/Mayor (actor #34) have the greatest degree, and can be regarded as the most influential in the response operation. Nonprofit Organizations (actor #41) and the US Military and Armed Forces (actor #13) are followed by New York State Government (actor #27). The similarity between the two results, Freeman's degree centrality measures and visual representation of the data in graph, can easily be captured. That other organizations share information with these five would seem to indicate a desire on the part of others to participate in network in response operations.

The following is the result from the degree group centrality calculated by UCINET for the optimal groups in network (Table 2). FEMA, HHS, New York City Government, American Red Cross, USACE, and nonprofit organizations were identified again as central organizations in the network.

Table 2. Degree Group Centrality

Observed # reached=41.000 (100.0%)	Observed no. reached = 30.000 (88.2%)
Group Members:	*Group Members:*
2 FEMA	3 FEMA
3 HHS	6 NYC Govt/mayor
6 DOT	7 Nonprofit Orgs
25 USAR	8 NY & NJ Port Authority
27 NY State Government	14 City Harvest, NY
28 CT Dpt of Health	18 USDA Forest Service
37 NYFD	20 Salvation Army
40 ARC	21 Southern Baptist Kitchens
41 Nonprofit Orgs	24 Catholic Charities of NY
Source: FEMA Situation Reports	Source: Interviews

Closeness Centrality

Degree centrality measures might be criticized because they only take into account the immediate ties that an actor has, rather than indirect ties to all others. One actor might be tied to a large number of others, but these others might be rather disconnected from the network as a whole. In this case, the actor could be quite central, but only in a local neighborhood (Wasserman and Faust, 1994). However, closeness centrality emphasizes the distance of an actor to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of these geodesic distances for each actor is the "farness" of the actor from all others. We can convert this into a measure of nearness or closeness centrality by taking the reciprocal (one divided by the farness) and normalizing it relative to the most central actor. Here are the UCINET results for closeness:

Table 3. Closeness using FEMA situation reports data

		Fairness	nCloseness
2	FEMA	42.000	95.238
13	U.S. Military Armed Forces	67.000	59.701
34	NY City Govt/ Mayor	67.000	59.701
3	HHS	68.000	58.824
35	NYC OEM	69.000	57.971
27	NY State Govt	70.000	57.143
20	NCS	70.000	57.143
10	USACE	72.000	55.556
18	EPA	73.000	54.795
37	NYFD	73.000	54.795
30	NJ OEM	81.000	49.383
29	NJ Dpt of Health	81.000	49.383
6	DOT	93.000	43.011
16	HUD	98.000	40.816

Actor #2 (FEMA) is the closest, or most central, actor using this method, because the sum of FEMA's geodesic distances to other actors (a total of 41) is the least. Four other actors US Military Armed Forces – USACE (actor #13), New York City Government/Mayor (actor #34), Health and Human Services (actor # 3), and New York City Emergency Management Office (actor #35) are nearly as close and thus are highly central organizations, HUD (actor #16) and the Department of Transportation (DOT) (actor #6), on the other hand, have the greatest farness.

Betweenness Centrality

Suppose that FEMA wants to exchange resources and information and work with NYCEMO. FEMA must go through an intermediate agency, NYC Government/Mayor for example. According to the strict rules of bureaucratic hierarchy, FEMA must forward the request through another governmental agency. The intermediate agency could delay the request, or even prevent the request from getting through. This gives a coordinating position to the organization who lie "between" the two organizations with respect to others. FEMA might use other agencies or channels to work with NYCEMO. Having more than one channel makes FEMA less dependent, a more central, and as more independent actor. Betweenness centrality views an actor as being in a favored position to the extent that the actor falls on the geodesic paths between other pairs of actors in the network. UCINET, it is easy to locate the geodesic paths between all pairs of actors, and to count up how frequently each actor falls in each of these pathways. The results from UCINET are:

Table 4. Betweenness

		Betweenness	nBetweenness
02	FEMA	652.629	41.835
34	NY City Govt/ Mayor	116.781	7.486
37	NYFD	90.183	5.781
13	U.S. Military Armed Forces	65.600	4.205
20	NCS	52.167	3.344
27	NY State Govt	46.360	2.972
3	HHS	45.460	2.914
18	EPA	39.943	2.560
41	Nonprofit Orgs	26.667	1.709
35	NYC OEM	21.250	1.362
5	CDC	13.167	0.844
39	Private Orgs	13.110	0.840
15	DMAT	8.000	0.513
10	USACE	6.443	0.413
7	USDA	2.743	0.176
40	ARC	1.500	0.096

It can be seen that there is a great deal of variation in actor betweenness. FEMA (actor #2) andNY City Government/Mayor (actor #34) appear to be relatively a good bit more central than others by this measure.

Flow Betweenness: Dynamics of Interorganizational Networks

The betweenness centrality measure I examined above characterizes actors as having positional advantage to the extent that they fall on the shortest pathway between other pairs of actors. The idea is that actors who are "between" other actors, and on whom other actors must depend to conduct exchanges, will be able to translate this central intermediary role into power.

If the two actors want to have a network relationship, but the geodesic path between them is blocked by an unwilling organization, and if there is another pathway, the two actors are likely to use it, even if it is longer and less efficient. The flow approach to centrality expands the notion of betweenness centrality. It assumes that actors will use all pathways that connect them to others proportionally to the length of the pathways. Betweenness is measured by the proportion of the entire flow between two actors that occurs on paths which connect them. For each actor, then, the measure adds up how involved that actor is in all of the flows between all other pairs of actors (Wasserman and Faust, 1994). Since the magnitude of this index number would be expected to increase with the size of the network and with network density, it is useful to standardize it by calculating the flow betweenness of each actor in ratio to the total flow betweenness that does not involve the actor (Everett & Borgatti, 1999).

Table 5. Flow betweenness

		FlowBet	nFlowBet
1	FEMA	795.727	51.008
2	HHS	97.754	6.266
3	DOD	2.167	0.139
4	CDC	27.294	1.750
5	DOT	0.000	0.000
6	USDA	4.497	0.288
7	GSA	6.167	0.395
8	DOE	0.000	0.000
9	USACE	7.176	0.460
10	SBA	0.000	0.000

By this more complete measure of betweenness centrality, FEMA (actor #2), U.S. Military and Armed Forces (actor #13), HHS (actor #3), and New York City Office of Emergency Management (actor # 35) are clearly the most important mediators. New York State Emergency Management Office (NYSEMO) (actor #31) and American Red Cross (ARC) (actor #40), who were fairly important when we considered only geodesic flows, appear to be rather less important by this calculation. While the overall picture does not change a great deal, the elaborated definition of betweenness does give us a somewhat different impression of who is most central in this network.

Cliques and Sub-groups: Groupings of Organizational Networks

Networks are also built up out of the combining of dyads and triads into larger, but still closely connected sub-structures. Many of the approaches to understanding the structure of a network emphasize how dense connections are compounded and extended to develop larger cliques or sub-groupings (Wasserman and Faust, 1994). A clique is simply a sub-set of actors who are more closely tied to each other than they are to actors who are not part of the group. This view of social networks focuses attention on how connection of large networks structures can be built up out of small and tight components.

Divisions of actors into cliques is a very important aspect of networks in understanding how the network as a whole is likely to behave. For example, suppose the actors in one network form two non-overlapping cliques; and, suppose that the actors in another network also form two cliques, but that the memberships overlap (some organizations are members of both cliques). Where the groups overlap, it can be expected that conflict between them is less likely than when the groups do not overlap (Hanneman, 2001). Where the groups overlap, resources can be mobilized and shared effectively across the entire network; where the groups do not overlap, resource sharing may occur in one group and not occur in others.

Knowing how an organization is embedded in the structure of groups within a net may also be important to understanding its behavior. For example, some organizations may act as "bridges" between groups (boundary spanners). Other organizations may have all of their relationships within a single clique (locals). Some actors may be part of a tightly connected group, while others are completely isolated from this group. Such differences in the ways that organizations are embedded in the structure of groups within in a network can have profound consequences for the ways that these actors see the network, and the behaviors that they are likely to practice to sustain or dysfunction the colloboration.

Table 6. Cliques

1:	FEMA NCS NY State Govt NY City Govt/ Mayor Verizon
2:	FEMA EPA NY State Govt NY City Govt/ Mayor
3:	FEMA HHS NY State Govt NY City Govt/ Mayor NYC OEM
4:	The President FEMA NY State Govt NY City Govt/ Mayor
5:	FEMA DOD NY City Govt/ Mayor NYC OEM
6:	FEMA CDC EPA NY City Govt/ Mayor
7:	FEMA HHS CDC NY City Govt/ Mayor
8:	FEMA USDA NY City Govt/ Mayor NYC OEM ARC
9:	FEMA USACE EPA NY City Govt/ Mayor

Table 6 suggests a number of things: FEMA, Verizon, HHS, NY City Government/Mayor, NYCEMO, USDA, and U.S. Military Armed Forces appear to be in the middle of the action in the sense that they are members of many of the groupings, and serve to connect them, by co-membership.

Figure 4. Hierarchical Clustering of Equivalence Matrix

```
         1   1 1 1 1     1 2       1 1 1 1   2     2
Level    8 9 5 6 1 2 5 8 7 0 1 2 4 0 9 3 4 3 1 6 7 2
-----    - - - - - - - - - - - - - - - - - - - - - - -
4.000    . . . . . . . . . . . . . . . . . . XXX . . .
3.000    . XXX . XXX XXX . . XXXXX . . XXX XXX XXX .
2.667    . XXXXX XXX XXXXX . XXXXX . . XXXXXXX XXXXX
2.222    . XXXXX XXX XXXXX . XXXXX . . XXXXXXXXXXXXX
2.178    . XXXXX XXXXXXXXX . XXXXX . . XXXXXXXXXXXXX
1.915    . XXXXX XXXXXXXXX . XXXXX . XXXXXXXXXXXXXXX
1.810    . XXXXX XXXXXXXXXXX XXXXX . XXXXXXXXXXXXXXX
1.641    . XXXXX XXXXXXXXXXX XXXXX XXXXXXXXXXXXXXXXX
1.507    . XXXXX XXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX
1.299    . XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX
1.249    . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1.057   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

We see that actors #2 and #21 are joined first as being close because they share 4 clique memberships in common. At the level of sharing only three clique memberships in common, actors #9, # 15, # 11, # 12, # 5, # 8, # 1, # 4, # 13, # 14, 3 6, and # 7 join the core. If we require only one clique membership in common to define group membership, then all actors are joined except # 18.

Much of what was observed on 9/11 and in the days and weeks that followed in New York City's massive destruction and social disruption, was a complex organized response. The immediate impact area was evacuated rapidly and in an orderly manner. After the collapse of the towers, the absence of panic saved numerous lives. Assisted by emergency workers, occupants of the World Trade Center and people in the surrounding area helped one another to safety, even at great risk to themselves. Prior experience with the 1993 Trade Center bombing had led to significant learning among organizational tenants and occupants of the Twin Towers, and planning and training contributed to their ability to respond in an adaptive fashion to highly ambiguous and threatening conditions.[3]

It has long been recognized by academics that disasters represent occasions in which the boundaries between organizational and collective behavior are blurred. Local capabilities are enhanced through the active involvement of nonprofit organizations. In the World Trade Center disaster, all these organizational patterns observed at Ground Zero: NYC emergency response organizations were assisted by counterpart organizations from throughout the tri-state region[4] and ultimately from communities around the country, by nonprofit organizations offering whatever assistance they could. Collective behavior brings charitable organizations with their needed resources to disaster areas while simultaneously creating substantial management challenges.

CONCLUSION

The insight of both network and complexity theories can help constructs interorganizational networks and help us understand their workings. Multi-sectoral collaboration involves creating new forms of relationships among organizations. In order to foster linkages and the trust that would enable accelerating coordination in emergency management response operations, the government should provide incentives and information to promote multi-sectoral colloborations.

The idea of interdependency has long been at the heart of organization design in complex environments. Despite the richness of theoretical developments, there has been relatively little formal investigation as to the extent to which interdependency among organizations can influence organizational adaptation over time in dynamic environments. This research represents a modest step towards understanding how organizational design can be used to help track the interorganizational coordination in emergencies.

Effective response and recovery operations require colloborations and trust between government agencies at all levels and between the public and nonprofit sectors. Ongoing collaboration raises trust, and the importance of broad collaboration among various governmental levels and between government, the private sector, the nonprofit sector, and the public cannot be overemphasized. In response to 9/11 a resilient emergency response was achieved through integrating the resources and capacity of emergency response organizations with other governmental agencies, private, and nonprofit organizations.

[3] Interview with NY & NJ Port Authority, 11/28/2003

[4] The Tri-State Metropolitan Region consists of nearly 20 million people living in Connecticut, New Jersey, and New York.

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