The Role of Social Networks In Crisis Situations: Public Participation and Information Exchange

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ABSTRACT

The goal of the paper is to discuss the framework for an interdisciplinary human-computer interactive technology that facilitates information and resource exchange and forms core groups for crisis management. The social networks discussed here are designed to incorporate local knowledge and participation and to foster institutional and academic ties by modeling interrelationships among global communities and exploring policy options. Social interactions between individuals and organizations are explored especially in situations when directed responses are helpful in predicting the complex interplay between social, political, and technological systems and practices that result in a transfer of information and resources in disaster situations. In the future, such networks shall identify patterns through which groups interact in responding to critical issues and shall incorporate more complicated actions by individuals and organizations allowing them to move away from a rigid path to manage disasters via the most situationally appropriate routes.

Keywords

Crisis management, crisis response, social networks, human-computer interaction

INTRODUCTION

Metcalfe's law states that the value of a telecommunications network is proportional to the square of the number of connected users of the network (Shapiro and Varian, 1999). While the mathematical justification measures the potential number of contacts, i.e., the technological side of a network, the social utility of a network depends upon the number of nodes in contact. In this paper, I discuss how the nodes are directed toward each other and how they form contacts via an interdisciplinary human-computer interactive model which facilitates information exchange between response workers and forms core groups of individuals engaged in crisis management. Organizational collaboration in the 2005 Hurricane Katrina is used as an example of such network analysis, where efforts indicate that a possibility for a “collaboration path” that connects all members of the network and a large fraction of potential long-range ties for social and geographical structure exists (Butts, 2009).

In the past decade crisis management has taken steps to anticipate and devise means to enable formation of contacts via newly developed technology, recognizing social interactions through sociological and mathematical models. Researchers in the social network field often borrow from graph theory to synthesize social networks that consist of sets of entities. The specific nature of these entities includes persons, groups, or organizations and displays characteristics based on their nature (Wasserman and Faust, 1994). Ties between these entities consist of a wide range of collaborations and interpersonal communications and are represented via graphs.

A graph is a relational structure between two elements: a set of entities (called nodes), and a set of entity pairs indicating connections among them (called ties). Recent work by Hipp and Perrin (2009) uses a model which combines social network theory and graph theory to measure the effect of group membership in a social structure on tie formation. Drawing on this line of work, I discuss tie formation as they are developed within virtual neighborhoods based on the impact of social factors and physical distance. The methods employed combine the use of spatial interaction functions (taken from geographical analysis) and graph models (taken from the social network analysis).

Reviewing Statement: This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

Like geography, the field of social network analysis has an extensive methodological literature. As Freeman (2004) summarizes, the network analytic field arose as the result of an interplay and integration among several initially independent streams of research within a number of disciplines, including anthropology, sociology, psychology, mathematics, and computer science. Using these methods, this paper investigates how the network identifies patterns through which people and organizations interact and form ties where appropriate, lending momentum to disaster relief.

A SOCIAL NETWORK APPLIED

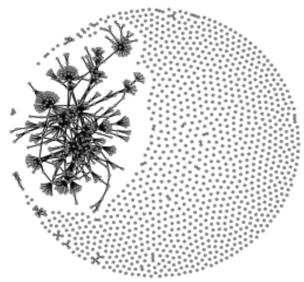

Figure 1. A Network of Organizational Collaboration in the Hurricane Katrina Response

Recent research conducted at the University of California, Irvine by Professor Butts shows the union of all accounts of organizational activity in a collaboration network for the Hurricane Katrina response. The primary materials used for the Butts study came from a collection of online situation reports (or "SITREPs") obtained from local, state, and federal emergency management agencies located throughout the United States. The research team georeferenced all organizations to the city level locations of their primary headquarters and coded all mentions of organizations involved in the Katrina response and all indicators of collaboration among them. This study produced a list of 1,577 organizations, with 857 instances of collaboration among them (Butts, 2009).

Professor Butts found that field interactions among organizations were strongly associated with contacts among their respective headquarters. In the diagram above, each grey circle represents one node in the network, and each black line represents one instance of collaboration between two nodes. A large cluster of connected nodes and their respective ties on the left side of the image, indicates that a "collaboration path" connects all members of the component. The nodes that form smaller clusters indicate smaller "islands" of collaboration and potential resources for the future (Butts, 2009).

Typically, during disasters, technology enables teams from across a continent to work together on alleviating a regional crisis. Thus, because a path exists between a given node in the lower portion of the component and a node in the upper portion of the component, a message or resources could traverse through the virtual network from one node to the other as long as there is a tie between nodes.

FORMING TIES

Since the goal of this paper is to facilitate information exchange between response workers and to form core groups of individuals engaged in crises management efforts, a look at what leads to a high level of teamwork (or tie formation) is essential. To address these matters, peacebuilding theory has questioned how peace-oriented civic organizations develop positive attitudes toward political engagement. Peacebuildig theory research found that connections that are stable over time and that recur across cultures are stable because they are formed out of win-win cooperation strategies between personal and group interests (Lave and Wenger, 1991; Medin and Atran, 2004).

In crisis situations factors such as political opportunity, organization of resources and their legitimacy, and individual attributes, such as education, determine participation (Verba, Schlozman and Brady, 1995). When people exchange information they begin to understand reality from a common perspective. Additionally, a step toward perceiving a situation from shared norms and rules is conducive to bartering, thereby facilitating mutually beneficial resource utilization (Verba, et al.,1995).

Thus, the degree to which information and resources are exchanged depends on 1) cultural stereotypes for the way the physical and social environments operate, and 2) principles of supply and demand. To that end, collaboration across populations is facilitated by knowing the history of economic, political, and military relations between and within groups. A human computer interaction model that learns to recognize these patterns within the sphere of interest and with the intention of creating ties will benefit crisis management efforts by establishing win-win scenarios.

MODELING CRISES MANAGEMENT NETWORK SYSTEMS

A choice of methodology for modeling is motivated by techniques that show how cultural knowledge is put into action to generate relevant connections between nodes. Specifically, similar to epidemiological models, where data is used to synthesize populations of interest and their activities thorough contact information (Diekmann and Heesterbeek, 2000), a crisis management system will first ensure that all crisis workers have a rate of contact with all other workers in the virtual community. The further objective of this model is to determine at which stage of the evolution a particular action is likely to arise and to simulate a situation where it would naturally arise in order to assist in handling an emergency (Bollobas, 2001; Erdos and Renyi, 1960).

Having established a rate of contact between crisis management workers, we look at the collective motion model to simulate virtual movement between nodes for the purpose of tie formation. This technique depends on the relative ratios of the spherical volumes around the nodes, i.e. the repulsion, alignment and attraction forces (alignment forces determine how individuals move along the predetermined gradient while attraction and repulsion forces determine how clusters occur) (Couzin, Krause, Franks, and Levin, 2005; Czirok, Barabasi and Vicsek, 1999). Interestingly, in their research Akkucuk and Carroll (2006) found that energy that is concentrated and driven by this three dimensional shape is similar to the driving force of evolutionary adaptation process.

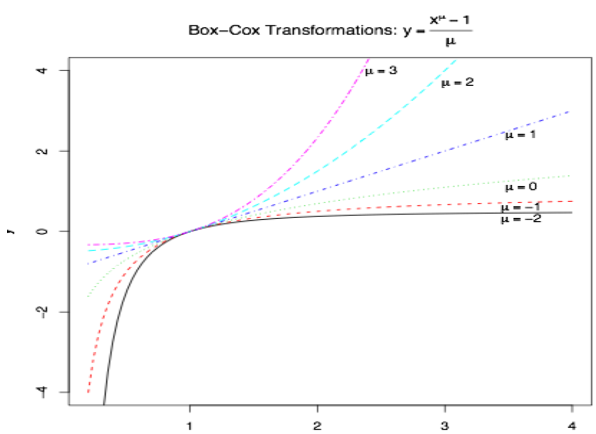

Figure 2. Box-Cox Transformations

The Box-Cox modification of power transformations above depicts how the attraction and repulsion ranges operate. As shown in Figure 2, the strength of "μ" determines both the power of repulsion and its inverse the power of attraction. Similarly, energy minimization determines clustering power "λ." For example, if clustering power $\lambda = 1/3$ and 1/4, energy functions have a weaker clustering effect than with the clustering power $\lambda = 1$ (Noack, 2003).

A Box-Cox parametrized family of energy functions tunes attractive and repulsive forces to reveal that a selected parameter for a critical mass of functions allows for differences of movement and clustering strength to be adjusted for desired outcomes (Chen and Buja, 2009). To this end, studies of collective motion models based on principles from mechanics and particle physics, already reinterpreted as social forces, convey that in any community individuals experience external cues of information about others' intentions as a force field on their velocity (Couzin, et al., 2005; Davidson and Harel, 1996; Fruchterman and Reingold, 1991). Similarly, cues will affect the majority of nodes in a virtual community where nodes represent assigned entities.

An analysis resembling the latter has also been made in economics where clustering of products of the same variety naturally evolved out of similar abilities and conditions. To measure how similar actions are correlated with one another, the concept of proximity studied by Cesar A. Hidalgo formalized an outcome based method founded on the assumption that countries producing similar products are more likely to export them in tandem; an existence of most suitable conditions for similar products dictated this outcome (Hidaldo and Hausmann, 2009). The researchers considered the probability for a product development given proximity to a similar product. Figure 3 below shows an example of how the chances for a country to develop a product increase enormously when that product is close to an already developed one - products can have a quadratic dependence on each other (Hidaldo, et al., 1990).

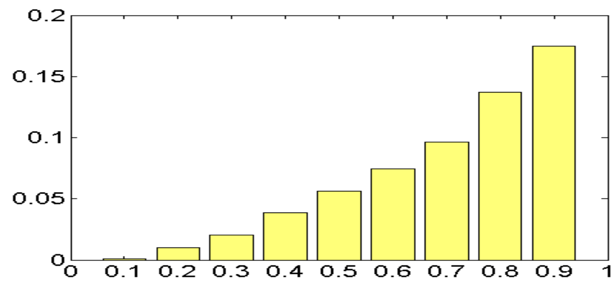

Figure 3. Probability of Increase in Product Output Given Proximity to Similar Products

For our purposes, a human computer interaction model that holds data regarding individual, group and organizational abilities will synthesize ties according to similar characteristics, thereby establishing conditions that reinforce naturally occurring phenomena. Thus, the clusters of groups attracted to the same goal will naturally evolve according to similar characteristics and nodes that use similar resources will gravitate toward each other forming mutually beneficial ties. Additionally, it is likely that their proximity to one another in virtual space will also have a positive correlation on their growth and development in handling emergencies. As a result, crisis management network systems that reinforce core groups of individuals interested in working together will also reinforce collaborations in emergency settings.

RESOURCE ACCESS

This model facilitates information transfer, development of ideas and opinion exchange, yet resource access is controlled via assigned degrees. Thus, if policy options require a degree of anonymity, a combination of attractive and repulsive forces are tuned to direct information flow.

Attractive forces are based on the properties of the nodes (such as target degrees) and the network properties of interest. As the attraction magnitude increases, individuals experience more attractive forces and move closer to one another, forming a cluster (Couzin, et al., 2005). Since nodes with similar degrees naturally evolve to having ties between them, those who are meant to preserve a degree of anonymity are conversely kept at a distance, separated by repulsive forces according to the assigned degrees (Keeling, 2005; Watts and Strogatz, 1998). Notably, adjusting a node's location and altering an existing tie potentially makes two new nodes available, and the new connections may improve resolution and convergence to the target degree sequence (Couzin et al., 2005).

CONCLUSION

An interdisciplinary human-computer interactive model that facilitates information exchange and forms core groups for crisis management is specifically designed to explore interrelationships between global communities and to synthesize the corresponding policy options. Its objective is to hold data regarding individual, group and organizational abilities and patterns of behavior in order to create ties according to similar characteristics, thereby establishing conditions that reinforce naturally occurring phenomena.

By systematically enabling teams to collaborate on providing relief in disaster situations, clusters of individuals that are attracted to the same goals are formed out of win-win ties. They naturally gravitate toward each other and evolve according to their own characteristics. The primary component in the graph therefore consists of organizations among which collaboration activity is the greatest, and the smaller components indicate potential resources to be developed and integrated.

Social networks discussed here are sensitive to local knowledge and participation and foster institutional and academic ties that hold a complementary scientific and cultural aim. Data for social interactions between individuals and organizations is further identified in situations when directed responses are helpful in predicting the complex interplay between social, political, and technological systems and practices that result in a transfer of information and resources in disaster situations.

Thus, in the future, such modeling of resource-human relationships shall identify patterns through which groups interact in responding to critical issues and shall incorporate more complicated actions by individuals and organizations, allowing them to move away from a rigid path to manage disasters via the most situationally appropriate routes.

REFERENCES

1. Akkucuk, U. and Carroll, J.D., (2006) Paramap vs. Isomap: A Comparison of Two Non-linear Mapping Algorithms, Journal of Classification, 23 (2), 221-254.
2. Bollobas, B. (2001) Random graphs, Cambridge Studies is Advanced Mathematics, 73, 2nd ed., Cambridge University Press, Cambridge
3. Butts, C. T. (2009) Revisiting the Foundations of Network Analysis. Science, 325, 414-416
4. Chen, L. and Buja, A. (2009) Local Multidimensional Scaling for Nonlinear Dimension Reduction, Graph Drawing and Proximity Analysis, Journal of American Statistical Association, 104, No. 485, 209-219.
5. Couzin, I.D., Krause, J., Franks, N.R., Levin, S.A. (2005) Effective leadership and decision making in animal groups on the move. Nature, 434, 513–516.
6. Czirok, A., Barabasi, L.A., Vicsek, T. (1999) Collective motion of self-propelled particles: Kinetic Phase Transition in one dimension, Phys. Rev. Lett. 82, 209-110.
7. Davidson, R. and Harel, D. (1996) Drawing graphs nicely using simulated annealing, ACM Transactions on Graphics, 15(4), 301-331.
8. Diekmann, O. and Heesterbeek, J.A.P. (2000) Mathematical Epidemiology of Infectious Diseases: Model Building, Analysis and Interpretation.Wiley Series on Mathematical and Computational Biology, John Wiley and Sons.
9. Erdos, P. and Renyi, A. (1960) On the evolution of random graphs. Publications of the Institute of Mathematics, Hungarian Academy of Science, 5, 17-60.
10. Freeman, L. C. (2004) The Development of Social Network Analysis: A Study in the Sociology of Science. Empirical Press, Vancouver.
11. Fruchterman, T. M. J. and Reingold, E. M. (1991) Graph drawing by force-directed placement, Software-Practice and Experience, 21(11), 1129-1164.
12. Hidalgo, C.A. and Hausmann, R. (2009) The Building Blocks of Economic Complexity, Proc. Natl. Acad. Sci. 106, 26, 10570-10575
13. Hipp, J. R. and Perrin, A. J. (2009) The simultaneous effect of social distance and physical distance on the formation of neighborhood ties. City and Community, 8(1), 5–25.
14. Keeling, M.J. (2005) The implications of network structure for epidemic dynamics. Theoretical Population Biology, 67.
15. Lave, J., & Wenger, E. (1991) Situated learning. New York: Cambridge University Press.
16. Medin, D., & Atran, S. (2004) The native mind: Biological categorization and reasoning in development and across cultures. Psychological Review, 111, 960 –983.
17. Noack, A., (2003) Energy models for drawing clustered small-world graphs, Computer Science Report 07/2003, Brandenburg Technical University at Cottbus, Germany.
18. Shapiro, C. and Varian, H.R. (1999) Information Rules, Harvard Business Press

19. Verba, S., Schlozman, K. L., and Brady, H. E. (1995) Voice and Equality: Civic Voluntarism in American politics. Cambridge, MA: Harvard University Press.
20. Wasseman, S. and Pattison, P. (1996) Logit models and logistic regressions for social networks: An introduction to Markov random graphs and p*, Psychometrika, 61, 3, 401-26
21. Wasserman, S. and Faust, K. (1994) Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge.
22. Watts, D.J. and Strogatz, S. H. (1998) Collective dynamics of small-world networks. Nature, 393, 440-2.