4.9. Social Network Analysis for Detecting the Web of Rare Event Planning and Preparation (Elisa Bienenstock, Pam Toman)

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Since September 11, 2001, the US Government has become increasingly interested in potentially-catastrophic events brought about through unprecedented human innovation. Such events are very difficult to anticipate and therefore very difficult to defend against. The US Department of Defense (DoD) in an effort to develop the capability to avert attacks of this sort is investigating methods and approaches to recognize the forensic markers of such an event preceding the attack.

Social network analysis (SNA) is both an approach to understanding social structure and a set of methods for analysis (Wasserman and Faust 2005) to define and discover those activities and associations that are indicators of these rare, high impact events. The planning and organization of an event of this type necessarily leaves a trail, as individuals from disparate realms coalesce to assemble the knowledge and skills required to bring about the catastrophe. The strength of social network analysis (SNA) is in identifying and analyzing the latent social structures that are activated to enable such an event.

For instance, immediately following the attacks of September 11, 2001, Valdis Krebs (2008), a social network analyst, published an analysis of the social connections between those involved in the attack. Subsequent SNA studies demonstrated how SNA not only allows for the visualization of ties between small numbers of already-identified individuals, but also provides a framework to understand how people, ideas, and nefarious plots propagate through social institutions. For example, Bienenstock et al. (2006) used SNA to investigate the social connections between ten key Islamic institutions and 38 major terrorist events. Figure 1 illustrates the importance of these institutions in linking together otherwise unconnected individuals into a terrorist network. This type of analysis is valuable for understanding the lifecycle of terrorist events and how they manifest in social networks. It offers a firm basis on which to continue to develop methodologies for revealing, prior to the attacks, the networks in which the actors operate.

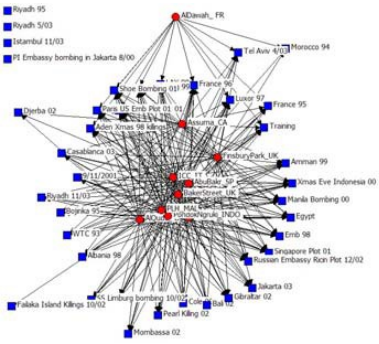

Figure 1. Connections of terror events through Mosque attendance and affiliations.

White Paper: Anticipating "Rare Events"

This paper describes insights from social network theory to propose a manner in which potential rare events may be recognized *a priori* through monitoring social networks of interest. Just as a spider notices strange vibrations in its web, the US Government could recognize changes to the normal state of the web of human connectivity that indicates marshalling of resources for nefarious purposes – before catastrophic events occur – given proper tools and capabilities. In particular, we examine two insights from the field of social network analysis: 1) the innovation necessary to conceive of these rare events originating at the periphery of the terrorist network, and 2) the organization of an event and how it generates activity in new regions of the network.

4.9.A. Characteristics of Rare Events from SNA Perspective

SNA is a broad and interdisciplinary endeavor that includes sociologists, physicists, mathematicians, anthropologists and others interested in exploring the effects of social structure on individual actions. The initial inspiration was to develop methods of analysis that enable the quantification and visualization of social relationships (ties) between people and/or groups (actors). Much of the early work and initial development of metrics and methods were born out of attempts to understand and formalize the social ties within a specific social group under investigation (Bavalas 1960, Coleman et al. 1957). SNA was primarily thought to be a set of tools to capture the implications of interactions within a group. The focus was on developing numerical operations that define social factors such as power, influence, status, discord and solidarity. While this early work focused on bounded groups, researchers quickly recognized the artificiality of bounding groups and began developing methods to traverse macro-level structure and the global network of human interaction (Poole & Kochen 1978, Killworth & Bernard 1979).

While SNA is useful for understanding the dynamics within a group, the more powerful theoretical insights gained from comparative network analysis concern the relationship between social network structure and what might be considered cultural outcomes. Patterns of interaction both define and reify culture which varies with network structure. One of the most basic findings relates network density and the degree of homogeneity to the ability of a social group to enforce normative behavior (Bott 1955, Bienenstock 1990). Related work discovered that structural properties associated with innovation (Coleman et al., 1957 Burt 1987).

The social network literature addressing the origins of innovation is particularly relevant to the rare events problem (Burt 1987, Valenti 2005). SNA research on small, well-bounded groups has discovered that innovation occurs not at the core of the group (or academic discipline), but at the periphery. In other words, it is not those most central to the discipline that tend to originate new movements within the group, but individuals who appear to be less central. Although this seems counterintuitive, it reflects the weakness of close, high-solidarity communities: they become provincial in thinking. From a more global, topological network perspective the periphery of one group is actually the avenue for connectivity between that group and the rest of the world.

In *The Strength of Weak Ties*, Granovettor (1971) argues that the best information on employment vacancies is prone to emerge from individuals outside one's routine social connections. The close friends with whom one speaks regularly cannot contribute the same value of information as those to whom one is connected tangentially. He points out that dense personal networks with high transitivity (where all associates know each other) become stale, as there are no sources for new information or ideas. As a result, from the micro perspective of the individual, there is a benefit in maintaining social connections in addition to one's daily intimate

relations; at a macro level, Granovettor's analysis indicates that innovation occurs at the interstices between dense regions of the network. For this reason the sparse areas of the global opened social network (or equally, the periphery of a bounded social network) deserve particular attention from those charged with trying to anticipate highly inventive (rare event) catastrophes.

Additionally, although high network density is strongly correlated with groups that require trust to operate and that value social control, such as covert, ideological or religious groups; few groups can completely enforce social constraints. Some members of these groups may seek relationships with "non-sanctioned" individuals. These peripheral members, who maintain ties both to the group and to others outside the group, are the conduits through which innovation can be introduced and even eventually adopted by the group. Additionally, these conduits expose the world to the unique perspective of that group.

Furthermore, the source of innovation is often the novel confluence of existing ideas. Although some argue that a truly rare event is by definition beyond imagination, others, such as social psychologists and social network analysts, disagree. New ideas are never truly new, but innovatively repackaged. The occurrence of a "new" idea requires sufficient precedent for someone to make the innovative leap; as a result, of course, a handful of individuals often arrive at the same innovation within a short time span. Novel ideas cannot be introduced to individuals from within a stale dense network, however. In order to obtain the freshness necessary to innovate, there must be inputs from the outside. New ideas, thoughts, and strategies are therefore more likely to present at the interstices between cultures and/or less dense network regions, and then be diffused inward to the rest of the network.

Human-engineered rare events imply innovation by definition. For an event to be rare, it requires a new technology, novel intent, available funding, or more likely, the combination of several of these in a previously-unattested form. Although the technology or insight behind a catastrophic rare event may not be obvious (if it were, the event would not be "rare"), the inspiration of that event is not necessarily unique. The event's rareness indicates only that the inspiration combined with intent and capability had not yet converged. The events of 9/11, for instance, were rare not because no one had ever thought about flying airplanes as weapons into buildings; some had in fact (Clancy 1994, Castaneda & Thomas 1994). The occurrence was rare because someone had managed to complete the operation successfully. Therefore, those interested in identifying rare events should pay particular attention to individuals located in groups with the skills or intent to intend such acts who are building connections in sparse regions of an existing social network.

4.9.B. Prediction of Rare Events from the SNA Perspective

Although SNA may prove a necessary tool for anticipating rare events, SNA alone is not a sufficient perspective from which to anticipate the planning or imminence of a rare event. To be useful, SNA must be used as a component of a more comprehensive strategy requiring cultural and domain knowledge, as well as other features. SNA, as an empirical and mathematical approach that derives insight from data, requires a directed and high-quality data collection and produces results in line with its well-founded theoretical orientation. For SNA to be predictive, it will require the development of new tools and methods based on existing theory.

Current theory suggests that intentional rare events would be preceded by activity in sparse regions of the global network. Activity in sparse regions would indicate the emergence of new ties that connect previously-unconnected regions. Detection of this sort of network evolution

would require a holistic and multilayered SNA perspective. A web of sensors informed by social network theory could be developed to monitor activity sensitive to particular types of connections. This web of sensors would provide a holistic awareness of the global environment that is also sensitized to specific activities; much like the spider's web alerts her to the location of even slight perturbations.

Although a global and multi-relational approach is recommended, utilizing SNA to anticipate rare events does not require the collection and monitoring of data on the entire network of all individuals at all times. While this would allow the detection of any unsavory connections building up between particular group clusters, it would also provide a large number of costly and invasive false alarms, as SNA focused almost exclusively on understanding bounded, well-defined networks of interest until recently. The recommendation here, rather, is to focus on the emergence of theoretically-determined patterns of ties in specific regions of the network. Connections formed in new regions would indicate: 1) the potential for innovation, as previously discussed, or 2) the gathering of necessary talent and materials to carry out a rare event. Social network theory provides an organizing schema to interpret the data and patterns of interactions.

The development of new ties at the edges of networks and the new involvement of individuals with particular talents and resources with each other serve as flags for the additional attention of the US Government. This approach to identification of potential rare events using SNA cannot be purely inductive, as such an approach would result in an unsustainable number of false positives that must be tracked or investigated. A more reasonable deductive-based approach would rather generate theoretical ideas for high impact events. The generation of theoretical ideas could in turn be informed by analyst knowledge about the thought patterns and interests of the particular groups and individuals between whom connections are ripe to form. With these hypotheses in hand, it would become possible to focus on the networks of groups or individuals with characteristics relevant to the potential event. In particular, analysts could then identify the talents and resources that will be needed for particular events, and look to the individuals in the network who possess these talents and resources. Analysts could then monitor these network regions for changes that might indicate the building of a capability of mass destruction.

Note that for rare events to be anticipated, the scenarios must include the most outrageous and preposterous scenarios imaginable. On September 10, 2001, most people would not have believed what was to happen the following day. Our biggest vulnerability may be the inability or unwillingness to take seriously, despite evidence, the prospect of a rare catastrophic event.

The application of SNA methodology, however is, useless when it is void of theory. Therefore the first and most important step in developing an SNA methodology directed at this type of problem is the development of possible rare event scenarios. This includes a set of possible "attacks" as well as information about what people, skills and materials would be required to implement each attack. Once these hypotheses are articulated, SNA could be utilized to investigate changes or locations in the social network where these components might converge.

4.9.C. Using SNA to Anticipate Rare Events: A Notional Example

Imagine the worst possible scenario, an intentionally produced Mega-Tsunami. In 2000, the BBC produced a documentary arguing that La Palma, Canary Islands, may potentially fall into the Atlantic Ocean. This event would cause a mega-tsunami 650 feet high, crossing the Atlantic at just under the speed of sound. By the time the tsunami met the Americas, the wave would be 3000 feet high. Such an event could potentially kill tens of millions of people and cripple the

United States. The question remains, could a motivated human group cause La Palma, Canary Islands, to fall into the Atlantic Ocean? If they could, what would they require in terms of talent, access, finances and material? SNA could be utilized to monitor the connections between individuals and groups whose convergence would indicate a plan to produce this type of event. Potential predictive / forensic markers on social networks would include: the formation of new ties between sub-networks with intent and individual with needed capabilities, such as physicists, geologists and demolitionists. In addition SNA techniques would link these individuals to the financing, material, political access and infrastructure required to carry out the plan.

The role of SNA in averting this catastrophe would be to:

1. determine what to monitor,
2. distinguish indicators of the formation of threat enabling ties, from the routine activity on the network,
3. posit, based on information available, the existence of ties for which there is no data,
4. identify critical points in the network that can be used as points of entry into the network to gather more data and investigate more deeply the motivation of the observed activity, and
5. determine the nth order effects on the network of COAs aimed at disrupting the planned activity.

Even if the La Palma event were not in planning, the data collection and analysis used to track these indicators may turn up evidence of another, not yet conjectured plot. The tools and talents needed for his type of catastrophe are not unique, another plan may be underway that could require much the same materials and people. The SNA approach described above, while designed for one purpose is not a stovepipe. By defining one scenario, as a target, the real utility of SNA is a general search for classes of social behavior that leave a tangible trail, that can be interpreted through the lens of social network theory as early warning indicators of plans to do harm.

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