Project Abstract

Network Topology and the Dynamics of Collective Action
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Michael W. Macy
Cornell University

Overall Mission/Objective.

What do flocks of birds, traffic jams, fads, forest fires, riots, internet search engines, and residential segregation have in common? The answer is self-organization. There is no leader bird who choreographs the dance-like movement of a flock of geese. There is no supervisor in charge of a riot. There is no librarian in a back room at Google headquarters who is busily classifying all the internet websites in a digital version of the Dewey decimal system. There is no conspiracy of banks and realtors who are assigning people to ethnically homogenous neighborhoods.

Traditionally, sociologists have tried to understand social life as a structured system of institutions and norms that shape individual behavior from the top down. In contrast, a new breed of social modelers suspect that much of social life emerges from the bottom up, more like improvisational jazz than a symphony orchestra. People do not simply play parts written by elites and directed by managers. We make up our parts on the fly. But if everyone is flying by the seat of their pants, how is social order possible?

New and compelling answers to this question are being uncovered by social theorists using an innovative modeling tool developed in computer science and applied with impressive success in disciplines ranging from biology to physics -- agent based computational modeling (ABCM). It is *agent-based* because it takes as a theoretical starting point a model of the autonomous, yet interdependent individual units (the “agents”) that constitute the social system. It is *computational*, because the individual agents and their behavioral rules are formally represented and encoded in a computer program such that the dynamics of the model can be deduced by step-by-step computation from given starting conditions.

Can social scientists learn something from models of self-organized behavior developed for understanding computer networks, bird flocks, or chemical oscillators? We believe they can, for three reasons. First, ABC models show how simple rules of local interaction can generate highly complex population dynamics that would be difficult (if not impossible) to model using traditional methods. Second, these models show how “social facts” can emerge *sui generic* at the population level, even when these properties do not exist at the level of the individuals. Third, these models can be used as virtual laboratories, to reveal the micro mechanisms responsible for highly complex social phenomena.

Progress and Preliminary Outcomes

Our research has led to several important discoveries about the diffusion of innovation and beliefs, including the spread of participation in collective action. Diffusion over social and information networks displays a striking regularity that Granovetter (1973) called “the strength of weak ties.” As Granovetter put it, “whatever is to be diffused can reach a larger number of people, and traverse a greater social distance, when passed through weak ties rather than strong.” The strength of weak ties is that they tend to be long – they connect socially distant locations. Recent research on “small worlds” shows that remarkably few long ties are needed to give large and highly clustered populations the “degrees of separation” of a random network, in which information can rapidly diffuse. We test whether this effect of long ties generalizes from simple to complex contagions – those in which the credibility of information or the willingness to adopt an innovation requires independent confirmation from multiple sources. Using Watts and Strogatz’s original small world model, we demonstrate that long ties not only fail to speed up complex contagions, they can even preclude diffusion entirely. Results suggest that the spread of collective actions and risky innovations benefit not from ties that are long but from bridges that are wide enough to transmit strong social reinforcement. Wide bridges are a characteristic feature of spatial networks, which may account in part for the widely observed tendency for social movements to diffuse spatially. Balance theory shows how wide bridges might also form in evolving networks, but this turns out to have surprisingly little effect on the propagation of complex contagions. Of greater importance is a threshold effect with a critical mass of low-threshold nodes.

Broader Impacts

Using our research program as a template, we are developing a curriculum for an innovative interdisciplinary social science seminar at the graduate level that will train students in agent based computational modeling. The goals of the seminar are three-fold. First, we want students to see how models of dynamical systems can inform theoretical research on collective action. Second, we want them to develop intuitions about how aggregate properties, such as network typology, can interact with individual decision making to affect the dynamics of propagation. And third, we want them to appreciate the importance of modeling propagation within structured networks, not in fully (or randomly) connected populations. Accordingly, the seminar introduces graduate students in political science, economics, and sociology to computational modeling, network analysis (focusing primarily on cascades), and collective action theory (including game theory). Students will also acquire sufficient hands-on training to understand and extend our JAVA libraries.

We have also created a public web site with examples of models. These models have intuitive graphical interfaces and will allow users to observe the effects of changing structural and behavioral parameters on the spread of collective action. This approach to formal modeling is far more accessible to novices than conventional analytical techniques that use systems of equations to describe population dynamics. Moreover, the application to problems of collective action (such as protest movements, panic behavior, and global warming) is far more compelling and engaging than highly abstract game-theoretic representations. We therefore anticipate a broad target audience for the web site, including graduate and undergraduate students of the computational and social sciences.
The third outreach component is a two-day international workshop on Games, Networks and Cascades, to be held at Cornell University in October, 2005. The workshop is bringing together

physicists, computer scientists, economists, sociologists and political scientists from Europe and the United States. We are working in a newly emerging field where progress will accelerate rapidly if we can overcome institutional, intellectual, and physical boundaries that obscure mutual awareness of theoretical and methodological advances. We plan to publish the proceedings of the workshop on-line and to include these in the graduate seminar.

Project Website

http://hsd.soc.cornell.edu/index.html