EDITORIAL

Networks and Complexity

Converging Streams of Research

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Understanding complexity and broad systems-level frameworks in the life, physical and social sciences has turned, in recent decades, to issues of network dynamics. Although network analysis has matured over many decades, as in the field of social networks [e.g., 1], only recently have classes of statistical and mathematical models been developed of sufficient breadth and power to accommodate more unified theories as well as foundational questions of dynamics and emergent structure. For example, to identify sources of similarity across hundreds of networks collected across species, Skvoretz and Faust showed how new statistical models (discussed in this issue) could be used to evaluate whether structural differences vary by classes of relations, such as influence, grooming, and agonistic encounters, as opposed to species-specific variance [2]. The growth of the World Wide Web, staggering advances in computing power and diminishing computational complexity of network algorithms, and demonstrations of the robustness and ubiquity of networks fitting small-world models [3] helped spark much of the recent cross-disciplinary explosion in network analysis and modeling. In these contributions, balancing the social with the physical and life sciences, each team or researcher was asked to reflect on the role of networks and network dynamics in their primary research areas.

The focus of this issue is on substantive research, using the powerful tools and theoretical parameters of network models. The contributions reflect emerging confluences of ideas and characteristics findings across the scientific disciplines. They help to show how network structure and dynamics provide keys to understanding complexity. Moving among different levels of network architecture, from the metabolic pathways that Andreas Wagner studies for clues to the origins of life, to the market networks that Harrison White studies to comprehend the organization and operation of the modern economy, we find broad theoretical conclusions about effects of network structure and the dynamics that produce them. These articles can only begin to reflect the vast scope of research initiatives being conducted worldwide on network dynamics and phenomena that emerge out of multi-level interactions. We hope they will help promote further cross-pollination of ideas and further demonstrate the power of network-based analyses and explanations.

Given the focus on substantive findings at different evolutionary levels, linkages between levels, modeling of structures and dynamics, and comparisons at different levels of organization, no attempt was made here to capture the enormous amount of work also being done on simulation and formal modeling, but major advances and convergences in this area will also be found in the reviews and citations. Issues of modeling, simulation, and mathematical or computational theorization might well make a future special issue on Networks and Complexity.

This special issue grew out of the August 2002 Founding Workshop for SFI's Network Dynamics Program, directed by James Crutchfield (Program Director, SFI) and Duncan Watts (Sociology, Columbia) and funded by Business Network member Intel Corporation. Many of those papers and their contributors are already well known to the community of complexity researchers, so the organization of the present issue, at the invitation of Harold Morowitz, was intended to bring in new contributors as well as some of those from the initial workshop. The workshop site http://discuss.santafe.edu/dynamics also contains a number of resources on networks and dynamics.

REFERENCES

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