Workshop: Network analysis & visualisation for simulation & prediction

Preface:

The Network of Experts [N/X] is associated with Technical Team NATO RTO IST059, which studies Network Visualisation. It held an informal workshop at Aerospace Corp, El Segundo, CA, USA, in November, 2007, the eighth in a series of such workshops.

The N/X has operated under the aegis of several generations of NATO Information Science & Technology technical teams, which have studied a series of visualisation topics that evolved from data mining to knowledge discovery. N/X workshops have occurred roughly biennially since 1994. The N/X and its workshops serve to provide a forum in which industry and university scientists can advise the parent technical group by discussing issues and research in visualizing data, information, knowledge and latterly, network and social dynamics.

The eighth N/X Workshop consisted a series of keynotes, provocations, breakout working groups and plenary sessions over three days, ending with a site visit to Jet Propulsion Laboratory. Throughout there were informal technical discussions over meals and breaks.

Amy K.C.S.Vanderbilt, USA, proposed some outstanding questions in the plenary:

1. How do we usefully assess if the behaviours of various types of networks are predictable over time?
2. When and how much are the behaviours of different kinds of network predictable?
3. Can network prediction tools and algorithms be sufficiently tested within simulated or modeled networks? How certain can we be that the results of such models will be applicable to a real-world situation?
4. What role does visualization play in measuring and understanding network predictability (or lack thereof) and the predictions (if any)?

"It comes down to this," she wrote:

> There are efforts from every branch of the military seeking to predict the behavior of terrorist cells and other networks given various influence factors. However, I am not so sure that all such networks behave with any degree of predictability. I am also not sure that they don't. This is a question that has not been addressed – perhaps because a viable definition/measure of predictability has not been formulated. But at the same time it is a question that needs to be addressed … .

Dynamic network analysis supports simulation and prediction methods for gaining insights into massive data sets refer to natural and artificial systems. Such datasets

comprise heterogeneous populations of objects (nodes and vertices representing agents and actors) representing, computer networks, social networks, networks of influence, infection networks, infrastructure vulnerability networks, or perhaps organizational hierarchies in a variety of networks.. These are not mathematical graphs. We deal with rather more complex networks in which the nodes and links have properties beyond being the vertices and edges in a graph.

Crucial to their analysis is the distinction between network topology on the one hand and the parameters that may usefully be visualised for simulation and prediction on the other. The topology is important, but it is only one of the aspects that may need visual presentation. Traffic density among the nodes may be needed by the tasks at hand, e.g., or the traffics' intent [beneficial or malevolent], or its bulk, or its information content, or any of a host of variables that may be tracked. Any or all nodes and links may be a large or small suite of properties that can be tracked--but which should be tracked, and which should be made visible? Answering that question is an art now, and it may never become a science.

With many empirical data sets from strategic and military intelligence sources, or from the public safety domain, or from criminal investigations, political science or economic studies, there comes a considerable challenge to discover and then display key network measures and attributes. The challenge goes beyond the problem of finding proverbial "needles in haystacks" through data mining. In order to simulate and predict the behaviour or state of such graph/networks, there is the subtler problem to distinguish which of potentially many parameters to visualize and how best to do so. In turn, that forces the question of how or whether the user-interfaces which now support data mining, may also display the newly chosen network parameters in order to support decision making.

Workshop organizers especially invited discussions of visualisation of graph/network simulation and prediction that span disciplines and afford useful applications in new domains such as the application of centrality measures in social networks to vulnerability assessment in computer networking environments or detection of key nodes in communications networks employed by adversaries.

The workshop format was similar to that of N/X and official NATO workshops organized by the associated NATO technical team in earlier years, at Penn State, Halden (Norway), Toronto, Wachtberg-Werthhoven (Bonn) and Copenhagen. That format makes extensive use of “provocations” – presentations lasting 15 minutes that are intended to stir discussion; for this Workshop we asked that a provocation pose a question or main point you consider important, for discussion. Discussion followed immediately for 10 minutes, extended later over coffee or meals.

As well as the provocation format, the workshop committee accepted short position papers were accepted from those who prefer that format. The plenary Powerpoint presentations and written abstracts and documents are attached in these Proceedings.

Every participant in the workshop joined one of three Breakout groups. The Breakout groups addressed the following topics:

- Developing a framework for network visualisation, to accommodate various ways of treating and understanding static and dynamic networks.

- Developing network datasets for research and understanding.

- And, Visualising uncertainty in network contexts.

The Breakout groups each presented their results at the end of the workshop. Those presentations are also attached.

Not surprisingly, the workshops did not answer the all of the questions asked in the plenary but there was a broad feeling that we made real progress particularly in defining the needs for datasets and recognizing the roles for modeling network dynamics and visualizing the results, to attack the problem suite. The reader will reach his or her own conclusions, on reading the breakout group conclusions.