

Preface

Networks composed of interacting, communicating, and co-operating processes provide powerful models for understanding the behavior of complex systems. The explosive development of the Internet in the last decade has made them pervasive in all aspects of our lives. It has also made possible their emergence as new models for applying computational techniques for solving and providing understanding for old problems with new insights. As such they often provide the framework for new methodologies that lead to better decision making in many fields such as transportation, communication, health, finance, and social engineering. Solving the many emerging problems in this area has required the collaboration of researchers from fields as diverse as mathematics, computer science, biology, economics, sociology, management science, and engineering.

Papers included in this volume originate from participants in a sequence of seven workshops on mathematics of networking (FP-NETS) I organized on behalf of Mitacs in the period 2010–2012. One important area of Mitacs research was the mathematical study and analysis of complex systems as this relates to and is inspired by the study and research and development of information technologies in the scientific and engineering communities. A major idea underpinning many of Mitacs' past research projects was also related to that of *dynamic network analysis* whereby *interacting communicating entities* process, exchange, and compute in order to attain optimal design goals. Applications can be found in all scientific and engineering areas: from wireless communication to network security, from cooperative and large-scale computing to social networking, and from financial analysis and risk assessment to cyber-warfare and understanding of war.

Overall, it appears that the networking field is somewhat siloed, with research approaches to problems in one type of networks, say biological, having common elements with those in linguistic networks. For example, many questions can be rephrased as shortest path problems, routing problems, max flow problems, min cost flow problems, etc., and heuristic techniques developed in one sub-area may be applicable in others. At the same time, networking often transcends the scientific boundaries of traditional fields like biology, economics, physics, and computer science. For example, commonalities are easily found in the study of the formation

of cellular systems by biologists, the origins of company networks by economists, alignment of atoms by physicists, and design of networks of computers by computer scientists.

In general, we are also interested in exploring how to organize and facilitate information acquisition, processing and acting in a large-scale system using adaptive techniques and local, sometimes restricted, channels of communication. One of the most powerful tools to emerge from the study of networking is computational methodologies that allow the testing and exploration of a wider range of more realistic models that may include dynamic parameters such as noise, motion, locality, etc. At the same time, models developed have been enriched by a vast wealth of applicable mathematical methodologies ranging from probability theory and statistics to graph theory, from combinatorial optimization to mathematical analysis and PDEs, from number theory to algebra, and from distributed computing to mechanism design that find applications in networking. The goal of this focus period on networking was to highlight application areas relevant to network analysis, identify new mathematical research areas that may provide insights, and enable cross-fertilization of ideas.

The focus period *FP-NETS: Focus Period on Recent Advances in Networking* organized and coordinated conferences, problem solving workshops, summer schools, plenary talks, and industrial academic panel discussions in selected, key areas of networking. The aim was to organize and run events pertinent to networking, promote the cross-fertilization of new ideas, as well as to support the participation of leading experts, faculty members, postdocs, and students from Canadian universities and international partner organizations. Activities included (1) tutorials that brought students and interested researchers up to speed, (2) invited talks by leaders in the field that illuminated state-of-the-art problems, (3) contributed talks by researchers, (4) panel discussions that elaborated and discussed important issues transcending current research problems, and (5) industrial and interdisciplinary exchanges. It also provided several opportunities for academics to brainstorm with research end users and identify relevant open problems. The outcome from each conference and workshop included the identification of open problems and ideas suitable for further exploration and collaboration. The focus period ended with a problem-solving interdisciplinary workshop with selected participants from all the networking workshops to interact and share expertise and ideas on important problems in networking.

Overall, the focus period FP-NETS attempted to provide a diverse and comprehensive forum to all interested researchers for understanding the most recent advances and developments in this important area. In particular, there were activities in the following networking themes: (1) Wireless Networking and Mobile Computing, (2) Network Security and Cryptography, (3) Social Networks, (4) Internet and Network Economics, (5) Biological Networks and Systems Biology, (6) Financial Networks and Risk Assessment, as well as a Problem solving workshop which concentrated on the solution of open problems resulting from the workshops. The current proceedings represent only samples of extensive discussions and scientific

presentations from three of these workshops, namely, Financial Networks, Network Security and Cryptography, and Social Networks.

Needless to say, organizing all these events would have not been possible without the support and encouragement I received from several people and organizations. First of all, in the last 14 years, my involvement with Mitacs (when it managed an NCE grant for research in the mathematical sciences) has been pivotal in shaping and enhancing my evolving understanding of the nature and beauty of mathematics. Mitacs has been a truly transformative organization in its efforts to change the mathematical culture not only in Canada but globally. The scientific discussions with the other members of the Research Management Committee shaped my mathematical focus. My interactions with Arvind Gupta have been inspirational. The logistical support and efficiency of Olga Stachove were always truly amazing.

Nilima Nigam and Rebekkah Marsh were very helpful in the initial stages of the planning while Michael Lynch was always present in supporting and guiding all the organizational aspects of the events. Also many thanks to Oscar Morales Ponce for helping to integrate the electronic files into a single volume.

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