Preface

In the context of network theory, *Complex networks* can be defined as a collection of nodes connected by edges representing various complex interactions among the nodes. Almost any large-scale system, be it natural or man-made, can be viewed as a complex network of interacting entities, which is dynamically evolving over time. Naturally occurring networks include biological, ecological and social networks (e.g., metabolic networks, gene regulatory networks, protein interaction networks, signaling networks, epidemic networks, food webs, scientific collaboration networks and acquaintance networks), whereas man-made networks include communication networks and transportation infrastructures (e.g., the Internet, the World Wide Web, peer-to-peer networks, power grids and airline networks).

This edited volume is a sequel to the workshop *Dynamics on and of Complex Networks* (*http://www.cel.iitkgp.ernet.in/∼eccs07/*) held as a satellite event of the fourth European Conference on Complex Systems in Dresden, Germany from October 1–5, 2007. The primary aim of this workshop was to systematically explore the statistical dynamics "on" and "of" complex networks that prevail across a large number of scientific disciplines. *Dynamics on networks* refers to the different types of processes, for instance, proliferation and diffusion, that take place on networks. The functionality/efficiency of these processes is strongly tied to the underlying topology as well as the dynamic behavior of the network. On the other hand, *dynamics of networks* mainly refers to the phenomena of self-organization, which in turn lead to the emergence of the complex structure of the network.

Another important motivation of the workshop was to create a forum for researchers applying the theories of complex networks to various domains as well as across several disciplines such as computer science, statistical physics, nonlinear dynamics, econometrics, biology, sociology and linguistics. The workshop received a large number of quality submissions from authors pursuing research in multiple disciplines, thus making the forum truly interdisciplinary. The total number of participants who attended the workshop

was approximately 40. There were around 20 speakers, including both senior researchers and young scientists, who spoke about the dynamics on and of different systems exhibiting a complex network structure.

The theme of this edited volume is identical to that of the workshop. Its primary aim is to show how the theories of complex networks are being successfully used by researchers to tackle numerous difficult problems in various domains. Towards this aim, it presents an extended version of some of the very high quality submissions received at the workshop together with new invited contributions, which can play an extremely important role in the understanding as well as advancement of the field. Since the target audience of this book is expected to be largely cross-disciplinary, the chapters have been made as readable as possible, explaining all the intricate technicalities wherever necessary in sufficient detail.

The uniqueness of this volume lies in the fact that it presents an equal mix of (a) very relevant reviews (eight chapters) of important works in the field, which gives the reader an up-to-date picture of the state of the art, and (b) independent research reports (eight chapters) providing a clear conception about how complex networks can be extremely useful in harnessing even the hardest problems of a particular discipline. The editors feel that research in this area has reached a stage where there is an urgent need to have a comprehensive knowledge of the past and the present before the future can be planned. The blend of reviews and the contributory chapters presented in this volume strive to achieve this objective and, thereby, set the platform for a "Phase II" research in complex networks.

The volume consists of three parts. The contributions in Part I center around the application of complex networks in the understanding of biological problems. This part consists of five chapters. The first chapter is *From Network Structure to Dynamics and Back Again: Relating Dynamical Stability and Connection Topology in Biological Complex Systems*, in which Sitabhra Sinha presents a study of how the topology of a biological network influences the nature of its dynamics, and conversely, how dynamical considerations put constraints on the network structure. The next chapter deals with *Regulation of Apoptosis via the NFκB Pathway: Modeling and Analysis*, in which Madalena Chaves *et al.* model and analyze, in the framework of complex networks, the interaction of the nuclear factor κB with the apoptosis signaling pathway. In the third chapter, *Network-Based Models in Molecular Biology*, Andreas Beyer presents a survey on the extensive literature that employs complex networks to understand numerous intricate phenomena in biology. The fourth chapter, *Ecological Networks: Structure, Interaction Strength, and Stability*, by Samit Bhattacharyya and Somdatta Sinha, presents a detailed survey of the various studies conducted on ecological networks and especially on food webs. In the last chapter, *Signaling and Feedback in Biological Networks*, Sandeep Krishna *et al.* review some important studies on the signaling and feedback mechanisms that are observed in different biological networks.

Part II is also spread over five chapters and focuses on social networks. This part begins with a chapter on *Topographic Spreading Analysis of an Empirical Sex Workers' Network*, by Johannes Bjelland *et al.*, where the authors present a "topographic" analysis of spreading (of HIV) on an empirical network of female sex workers. The authors find that the HIV graph breaks into small components, thereby reducing the spreading if perfect condom protection is made possible. The next chapter, *Spectral Characterization of Network Structures and Dynamics*, by Anirban Banerjee and Jürgen Jost, centers around the investigation of the spectral properties of complex networks with a special thrust on social networks. The third chapter, *Dynamics of Social Complex Networks: Some Insights into Recent Research*, is authored by Sergi Lozano and presents a comprehensive review of how complex network theory has been instrumental in explaining the structure and the dynamics of a society. The last two chapters show how complex networks can be applied to explain the dynamics of human languages. The first one, titled *The Structure and Dynamics of Linguistic Networks*, by Monojit Choudhury and Animesh Mukherjee, is a review of the current literature on linguistic networks. The second one, *Networks Generated from Natural Language Text*, by Chris Biemann and Uwe Quasthoff, presents a survey focusing on how corpus linguistics (i.e., the study of language as expressed in corpora) can be studied within the framework of complex networks.

Part III presents a comprehensive overview of the networks that are prevalent in information sciences. This part is laid out in six chapters. The first chapter in this part, *Efficiency of Navigation in Indexed Networks*, by Petter Holme, explores the efficiency of navigation of data packets on "indexed" graphs. The second chapter, *Evolution of Apache Open Source Software*, by Haoran Wen *et al.*, attempts to explain the evolution of the Apache open source software through the analysis of its call graphs. The next chapter, *Some New Applications of Network Growth Models*, by Gourab Ghoshal, presents new models of growth for peer-to-peer file-sharing networks. The fourth chapter, *The Big Friendly Giant: The Giant Component in Clustered Random Graphs*, by Yakir Berchenko *et al.*, is a theoretical study of the properties of the giant component in a special kind of random graph, which is relevant for various information networks. The fifth chapter, *Technological Networks*, by Bivas Mitra, presents a detailed review of the large number of studies that have been conducted on information networks, especially the World Wide Web and peer-to-peer networks. The last chapter, *Advances in the Theory of Complex Networks*, by Fernando Peruani, presents a survey of some of the theoretical advancements that have taken place and helps in providing a better understanding of the structure and dynamics of information networks.

These contributions collectively demonstrate that complex networks indeed provide an elegant research framework relevant to a variety of scientific disciplines. The chapters are designed to serve as the state of the art not only for students and new comers who intend to pursue research in this field but

also for the experts. All the chapters have been carefully peer reviewed for their scientific content as well as readability and self-consistency.

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