

Preface

“Network science” has recently attracted the attention of a large number of researchers from various disciplines, mainly due to its ubiquitous applicability in modeling the structure and dynamics of large-scale complex systems (both natural and man-made). Examples of such systems, exhibiting complex interaction patterns among their constituent entities, range from genetic pathways and ecological networks to the WWW, peer-to-peer networks, and blogs and online web-social networks.

Dynamics on networks refers to the different types of so-called processes (e.g., proliferation and diffusion) that take place on networks. The functionality/efficiency of such processes is strongly affected by the topology as well as the dynamic behavior of the network. On the other hand, *dynamics of networks* mainly refers to various phenomena (e.g., self-organization) that go on in order to bring about numerous changes in the topology of the network.

A first systematic exploration of the above field materialized into an edited volume: *Dynamics on and of Complex Networks: Applications to Biology, Computer Science and the Social Sciences* published by Birkhäuser (ISBN: 978-0-8176-4750-6). With a rich collection of surveys and cutting-edge research contributions exploring the interdisciplinary relationship of dynamics on and of complex networks this volume served as one of the pioneers of research in this field. The entire piece was thematically organized into three main sections: Part I studies the application of complex networks to biological problems; Part II focuses on social networks; and Part III is an overview of networks prevalent in the information sciences.

With the progress of this field, it is becoming more and more apparent that the current challenges lie in understanding and solving problems that arise in dynamically changing networks, i.e., whose structure as well as function can both change with time. Examples include dynamic trafficking networks, telephone/mobile communication networks, or web-social networks. The processes that essentially take place on top of such networks are also dynamic, i.e., processes like epidemic spreading or the opinion formation co-evolve over time along with the underlying network. This second volume aims to put forward burgeoning multidisciplinary research contributions that combine methods from computer science, statistical

physics, econometrics, and social network theory towards modeling time-varying social, biological, and information systems. This volume deems to significantly contribute to the scientific advancement of the field of complex networks and, most importantly, dynamically changing networks that has also been continuously, for the past two years, the central theme for the workshop series *Dynamics On and Of Complex Networks*, held in conjunction with the European Conference on Complex Systems. A closer inspection would make it clear that the issues and the related problems in this area are still very loosely defined. Therefore, in summary, the primary objective of this volume has been to tie these loose ends through in-depth review chapters and concretize new problems that need to be urgently addressed in this area through cutting-edge contributory chapters.

This volume consists of three parts. The contributions in Part I center around the dynamical properties of online social networks, the Internet, and the WWW. This part consists of five chapters. The first chapter, “Dynamics in Online Social Networks” by Grabowicz et al., describes some of the results of research studies on the structure, dynamics, and social activity in online social networks. In the next chapter, “An Empirical Validation of Growth Models for Complex Networks,” Mislove et al. use empirical growth data from four different networks (the Flickr and the YouTube online social networks, Wikipedia’s content graph, and the Internet’s AS-level graph) to validate proposed models for the generation of power-law networks. In the third chapter, “On the Routability of the Internet,” Erola et al. present methodologies based on complex network theory to construct navigable maps of the Internet to address the problem of the scalability of the Internet routing protocols. The fourth chapter, “The Evolution of Layered Protocol Stacks Leads to an Hourglass-Shaped Architecture” by Akhshabi et al., studies the Internet protocol stack and their evolution in a rigorous and quantitative manner. They propose an “EvoArch” model which predicts the emergence of an hourglass architecture and the appearance of few stable nodes (not always of the highest quality) at the waist of the hourglass. In the last chapter, “Opinion Dynamics on Coevolving Networks,” Federico Vazquez describes some of the most representative opinion dynamics models on evolving networks.

Part II is spread over seven chapters and focuses on community analysis which at this point in time constitutes as one of the “hottest” areas of research in this field. This part begins with the chapter “A Template for Parallelizing the Louvain Method for Modularity Maximization,” where Bhowmick et al. introduce a shared memory implementation of the popular Louvain method for maximizing modularity. They discuss the challenges in parallelizing this algorithm as well as metrics for evaluating correctness while handling large-scale data. The next chapter, “Multi-scale Modularity and Dynamics in Complex Networks,” is authored by Renaud Lambiotte and focuses on the detection of communities in multi-scale networks, namely networks made of different levels of organization and in which modules exist at different scales. The third chapter, “Evaluating the Performance of Clustering Algorithms in Networks” by Andrea Lancichinetti, introduces a new model of benchmark graphs whose features are close to those found in real networks for evaluation of clustering algorithms. The fourth chapter, “Communities

in *Evolving Networks: Definitions, Detection and Analysis Techniques*” by Aynaud et al., exposes a survey of recent advances in the definition, the detection and the analysis of communities in the particular case of evolving networks. The fifth chapter, “Clustering Hypergraphs for Discovery of Overlapping Communities in Folksonomies” by Chakraborty et al., presents the overlapping-hypergraph clustering algorithm, which detects overlapping communities in folksonomies using the complete tripartite hypergraph structure. The sixth chapter, “The Stability of a Graph Partition: A Dynamics-Based Framework for Community Detection” by Delvenne et al., develops a dynamical perspective towards community detection by introducing a stability measure that provides a unifying framework enabling deeper understanding of what a community structure is. In the last chapter, “Algorithms for Finding Motifs in Large Labeled Networks,” Khan et al. introduce different kinds of subgraph analysis problems and discuss some of the important parallel algorithmic techniques that have been developed for them.

Part III presents an overview on diffusion, spreading, mobility, and transport on networks. This part is laid out in four chapters. The first chapter in this part, “A Dynamical Network View of Lyon’s Vélo’v Shared Bicycle System” by Borgnat et al., discusses the dynamical properties of Lyon’s shared bicycle system called Vélo’v. In the second chapter, “Generalized Voter-Like Models on Heterogeneous Networks,” Moretti et al. presents a generalized model of consensus formation that, which is able to encompass all previous formulations of copy/invasion processes inspired by variations on the voter model and the Moran process. The authors consider the implementation of such generalized dynamics on a heterogeneous contact pattern, represented by a complex network, and derive the theoretical predictions for the relevant dynamical quantities, within the assumptions of the heterogeneous mean-field theory. The next chapter, “Epidemics on a Stochastic Model of Temporal Network” by Rocha et al., presents a simple and intuitive stochastic model of a temporal network and investigates how a simulated infection coevolves with the temporal structures, focusing on the growth dynamics of the epidemics. The last chapter, “Network-Based Information Filtering Algorithms: Ranking and Recommendation” by Matúš Medo, gives an overview of applications of random walks to information filtering, focusing on the tasks of ranking and recommendation in particular.

The aforementioned contributions collectively demonstrate that dynamic networks indeed provide an intellectually deep research area relevant to a variety of scientific disciplines. The chapters are designed to serve as the state of the art not only for students and newcomers but also for experts who intend to pursue research in this field. All the chapters have been carefully peer-reviewed in terms of their scientific content as well as readability and self-consistency.

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