New Generation Computing, 32(2014)187-192
Ohmsha, Ltd. and Springer

Preface

Propagation Phenomenon in Complex Networks: Theory and Practice

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Received 24 March 2014

§1 Introduction

The domain of complex networks is one of the most active areas in contemporary computer science. Over the past several years, numerous mechanisms of propagation, in particular the propagation of error, have gradually become very important features of every complex network. Studying these phenomena enables us to better understand the spread of information or action in a network, which in turn may lead to the improvement of its performance and robustness.

The present double issue of New Generation Computing is devoted to propagation phenomena occurring in complex networks. Propagation characteristic depends heavily on network topology, individual or collective behaviour and interconnected chains of cause and effect including the so-called 'butterfly effect' relationship. In response to many types of serious effects including disturbances, crashes, and potential catastrophes, understanding propagation properties may be important when designing, implementing, maintaining and developing existing complex networks.

Traditionally, the term 'propagation phenomenon' is used in the computer research community to describe the properties of wider dissemination in a system, either automatically or semi-automatically. This propagation concept can be described by several synonymous terms in the literature, such as spreading and diffusion, though their origin is somewhat different. Frequently occurring propagation-related examples include information diffusion, message broadcasting, forwarding memes, rumour dissemination, flooding algorithms, disease spreading, percolation modelling, warm replication, contagion effects, cascading failures, and economic fluctuations. Considering this problem we face propagated messages, contacts, news, gossip, beliefs, queries, actions, conflicts, diseases, computer viruses, traffic congestion, constraints, failures, programming exceptions and more recently risk, trust and even uncertainty. Among the variety of features observed, the most interesting and still intriguing propagation phenomena include: epidemic spreading, opinion formation, seeding strategies, cascading failures, and finally the effective interaction between process topology and dynamics in time-varying networks.

The immediate purpose of this editorial is to provide a brief review of the papers that follow and suggest some ways for the reader to better contextualize a significant area of research presented here. However, the long-term goal is to encourage further discussion in future issues of the journal through the introduction of some new perspectives on propagation processes in complex networks.

§2 Organisation of the Issue

An impressive breadth of research appears in this issue. We have gathered a group of interesting papers on some of the most important topics in propagation-related complex networks. A total of twenty five papers from sixteen countries were prepared and submitted. After an extensive review process, we selected eight papers of sufficient standard and impact, following the journal procedures. These papers cover a wide range of topics related to propagation phenomena in complex networks, including epidemic and social spreading, failure and information cascades, preferential attachment, rewiring in a network, community detection and finally an agent-based population learning algorithm.

The issue opens with the two contributions on the spreading phenomena to study the combination of epidemic-opinion dynamics and the static-temporal approach, respectively.

Ye Wu, Mingjie Li, Jinghua Xiao, Mehmet A. Orgun and Liyin Xue, authors of the paper 'The Impact of Discrimination on the Spread of Infectious Diseases in Complex Networks' focus on the influence of epidemic-related discrimination against infected individuals in the spread of diseases. The interaction of human behaviour, such as the breaking of social ties or those introduced by voluntary vaccination, on the spread of diseases in a community has been studied considerably in recent literature. Notwithstanding the efforts of the researchers, some interesting problems still remain open. In this contribution, the authors introduce the asymptomatic SIS model which covers not just one but both of the positive and negative effects in terms of the behaviour of infected individuals. The following parameters of opinion dynamics have been investigated: the individual sensitivity of discrimination, the external influence, and the social temperature. Their findings showed that i) generating a strong positive external impact, and ii) dropping the social temperature followed by decreasing the individual sensitivity, will reduce the epidemic threshold.

In the second study, 'Seed Selection for Spread of Influence in Social Networks: Temporal vs. Static Approach,' Radosław Michalski, Tomasz Kajdanowicz, Piotr Bródka and Przemysław Kazienko present their solution to the problem of how to leverage historic knowledge relating to nodes' activity to select a 'best' set of seeds to maximise the number of influenced nodes in the propagation process. In addressing this problem, the authors use the linear threshold model and users' rankings based on time-aggregated values of typical structural network measures (*in-degree*, *out-degree*, *total degree*, *betweenness* and *closeness*). They couple these measures with various forgetting factor mechanisms and present results on simulations over N-windows real-world social networks. They demonstrate that a dynamic windowed approach gives better results for seed selection than a static network model and confirm this statistically. In particular, the *out-degree* measure with exponential forgetting factor yields top performing results.

Cascade problem in real-world networks is the central topic in the next two contributions.

The first of these papers 'Assessing the Impact of Cascading Failures on the Inter-domain Routing System of the Internet' by Yujing Liu, Wei Peng, Jinshu Su and Zhilin Wang shows how cascading failures propagate in the Internet. The authors propose CAFEIN model for assessing the difference of impact under intentional attacks and random breakdowns, identifying the worst affected part of the Internet and studying the propagation of cascading failures. *Reachability* of inter-domain routing systems and *number of rerouting messages* are proposed for measuring the impact of cascading failures. They confirm that the cascading effect under intentional attack is still greater, but less than expected under random breakdown, even by the automatic restoration process of some faulty links in the inter-domain routing system. Their results are of paramount importance for the defence against intentional attack, the recovery from failure, and the improvement of routing protocol for next generation networks.

The same line of research, aimed at investigating a game theoretic cascade model, is explored by Mahsa Shafaei and Mahdi Jalili in 'Community Structure and Information Cascade in Signed Networks.' Their contribution uses network coordination games, where the benefits of individual nodes depend on decisions made by their neighbours. A model and real social networks with positive (trust or friendship) and negative (enmity) links (recommendations) are analysed and clustered to find an influence of community structure on cascade depth indicating the number of nodes that have changed their behaviour. The direct influence in signed networks is found. Specifically, as the number of intra-community negative links increases, so does the number of nodes that have participated in the cascade. In contrast, increasing the number of inter-community links with positive sign deteriorates the cascade depth. Their experiments on two signed data sets, who-trust-whom online *Epinions* network and friend/foe links between the users of *Slashdot*, confirm that social balance plays a significant role in information cascade.

Another popular area where propagation methods are highly topical is the field of software systems evolution perceived as directed networks. This is the focus of the paper 'Symmetric Preferential Attachment for New Vertices Attaching to Software Networks' by Hui Li, Li-Ying Hao, Rong Chen, Xin Ge and

Hai Zhao, where a model which describes how new nodes and links attach is proposed. The authors explain that the current interest in the evolution of software networks comes from the fact that the complexity of software systems is consistently increasing. At first, they examine the correlation between the degree of the existing vertices and the number of newly incoming/outgoing connections. Then they propose the mechanism of symmetric preferential attachment. Finally, they test the theoretical research they have presented on 10 open source software products. This work not only indicates the adaptivity and reusability as an effective tool against error propagation, but also helps us gain profound understanding of the dynamical evolution of contemporary software systems.

After this part with distinctive recognizable topics on spreading and cascading always quoted as fundamental propagation examples, the issue proceeds to theoretical concepts to gain new insights into old notions. The effects of assortativity on the topology of a network and process dynamics and the use of assortativity as a performance measure are the central topics in the following two contributions.

Rong Yang's paper, 'Assortifying Networks,' presents two algorithms - a rewiring algorithm and its modification with community structure preservation - yielding results concerning the assortativity of networks. The assortativity is expressed by means of differences between node degrees and the average degree of the network nodes. An Erdős-Rényi graph and a computational geometry collaborations network are used to demonstrate the effectiveness of the proposed method for modifying a given network so as to either increase or decrease its assortativity while preserving the degree distribution of the network. Assortifying networks is of critical importance to a greater knowledge of many processes on networks, including the effect on epidemic thresholds, and information cascade probabilities, and targeted immunization.

The next contribution, 'Integrating Concepts and Knowledge in Large Content Networks' by Marco Rossetti, Remo Pareschi, Fabio Stella and Francesca Arcelli Fontana, addresses the integration into semantically consistent knowledge bases of contents residing in large networks like the World Wide Web. The authors treat this objective as a problem of community detection among textual objects such as Web pages and each detected community corresponds to a specific topic (concept). Topics and objects are then structured and organized into topic-topic and object-object networks, hence providing the groundwork for a navigable and semantically consistent knowledge base. The applied methodologies are based on the exploitation of techniques for semantic analysis derived from probabilistic topic modelling through Latent Dirichlet Allocation. Since the contents that are integrated originate from multiple independent sources, and thus are only sparsely connected via hyperlinks or similar constructs, it is also shown that such methodologies perform generally better at community detection under the given circumstances than purely structural methods like Harel and Infomap. Analysis and comparison of the methods are based on the four performance measures: YAGO similarity, symmetrized Kullback-Leibler divergence, modularity and assortativity. The first two measures evaluate the semantic coherence of discovered communities, while to evaluate the quality of the partitioning of a graph structure, the modularity and the assortativity performance measures have been selected.

The issue closes with a paper 'Designing RBF Networks Using the Agent-Based Population Learning Algorithm' by Ireneusz Czarnowski and Piotr Jędrzejowicz. The papers reported in this issue cannot fail to forget the conventional backpropagation algorithm used for the multilayer perceptrons training. In this paper, an agent-based population learning algorithm using an A-Team architecture is proposed to optimize parameters in both stages of the Radial Basis Function networks integrated design process, i.e. initialization and training. To validate this collaborative approach, an extensive computational experiment and a statistical analysis have been carried out. Performance of the presented algorithms has been evaluated using several benchmark datasets from the UC Irvine Machine Learning Repository.

Finally, we hope that this special collection may inspire, sometimes irritate and astonish, but above all, that it will provoke discussion and further research. It is also an attempt not only to know better and respect propagation issues, but to open up and to find out more about propagation in complex networks with implications of the present findings for both theory and practice.

Acknowledgements

The idea of organizing this special issue was shaped in the context of the project, *To what extent can design principles for complex networks be derived from the study of error propagation phenomenon in smart and bio-inspired network structures?* within the 7th European Community Framework Programme under grant FP7-PEOPLE-2010-IEF-274375-EPP. This special issue depends on hard work of many people who deserve credit and thanks. First, let me thank all contributors to this special issue. Without these excellent contributions, we would have not been able to show what propagation phenomenon has currently to offer to the field of complex networks. We are also grateful to the reviewers who made critical and valuable comments and suggestions that helped to improve the papers. The Reviewer Board of this issue is composed of the following members: Nuno Araujo, Emili Balaguer-Ballester, Abdelhamid Bouchachia, Marcin Budka, Frantisek Capkovic, Richard Clegg, Anirban Dasgupta, Paul Davidsson, Gabriele D'Angelo, Jeremiah Deng, Damien Farine, Damien Fay (special thanks for his help), Bogdan Gabrys, Sergio Gomez, Jesus Gomez-Gardenes, Nathan Griffiths, Jason J. Jung, Krzysztof Juszczyszyn, Jrme Kunegis, Mirco Musolesi, Katarzyna Musial-Gabrys, Ngoc Thanh Nguyen, Andrea Omicini, Witold Pedrycz, Mart Rosas-Casals, Antonio Scala, and Mirko Viroli. And now, last but not least, we are especially grateful to Toyoaki Nishida for his confidence and constant support.

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