

Networks of Networks: The Last Frontier of Complexity-A Book Review

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Abstract – Along this work the book "Networks of Networks: The Last Frontier of Complexity", 978-3-319-03517-8 published in Springer Series "Understanding Complex Systems" is reviewed. This book theme importance is evident and enormous since it deals with something essential to nowadays everybody's life, the "Critical Infrastructures". In the various chapters these devices are studied, exemplified and modelled in order to find the tools to solve their problems of governing, managing, maintenance, security and preservation (with special attention to natural catastrophes problems). It is emphasized that their performance and effectiveness depend not only on the reliable physical components but also on the human behavior understanding at individual and collective levels.

Keywords – Networks, networks of networks, complexity.

1. Introduction

In the preface of this book the main Editors, Gregorio D'Agostino and Antonio Scala, begin identifying the infrastructures on which rely the modern life in fully developed countries and nominee, among others, Electric Systems, Aqueducts, Communication Assets, Fresh Food Distribution Chains, Gas Ducts, Oil Pipelines, Transports and Financial Networks. Then emphasize that their availability depend not only on the reliable physical components but also on the human behavior understanding at individual and collective levels.

Then call the attention for the inter-dependence of these critical infrastructures, easily perceived and admitted in any common sense approach.

Evidently, a global conceptual approach of this kind of system configures one the following devices:

- A huge network of networks,

- A lot of networks of networks.

The last, chosen in this book, configures a much more intuitive and understandable analysis mode.

The situation described above is the one of a complex problem in the sense that very little is known about it. And then constitutes a very promising and interesting field of research demanding an interdisciplinary approach.

All this justifies the title of the book: "Networks of Networks: The Last Frontier of Complexity" and the papers in it are in accordance.

Still in the preface, the main Editors enumerate some, among others of course, Information-based services provided to our developed society: Web, E-mail, E-commerce, E-health, Web-based entertainment, SCADA systems, ... to conclude that the infrastructures are required to become smart into a smart technological environment. Of course this establishes new challenges to be overcome getting more and more knowledge, through more and more research, on Networks of Networks.

The book is composed of three parts: Theoretical Approaches, Applications and Phenomenological Models. In the sequence of this review a section is devoted to each one. Then there will be a section on the mathematical models used in the book and finally, in the last section, an overall review, synthetizing the former sections, is presented.

2. Theoretical Approaches

The first part, "Theoretical Approaches", constitutes a general overview on the Networks of Networks (Net O Nets) in particular on the Interdependent Networks that are the ones that really interest. These part chapters are contributions stemming from the

Statistical Physics approach.

As modeling Interdependent Networks consists in defining different graphs and the interaction among them, two different approaches are used and explained:

-Multiplex Approach,

-Interacting Networks.

Static approaches are considered in chapters 1-3 and the dynamics of the systems in chapters 4, 5.

Chapters 1-5 are theoretical and conceptualizing. They constitute the basis supporting the interventions in these structures. All are almost surveys on this subject. An approach close from the ones typical of Statistical Physics makes sense.

Being maybe the most difficult part to read, it is very delightful.

3. Applications

In the second part, "Applications", very interesting examples of Networks of Networks applications are presented:

-Epidemic propagation,

-Traffic Routing,

-Electrical Power System Blackout Mitigation Strategies,

-The fact that Complexity Power Systems does not reduce to the Interaction among Physical Components,

-And, to end this part, quite surprisingly, not a common critical structure, but the most complex "system of systems": The Human Body.

In general, the whole book is devoted to the problems of governing, managing, maintenance, security and preservation (with special attention to natural catastrophes problems) of these Critical Structures here considered Networks of Networks. And the number and choice of practical examples considered allow saying that from this point of view it is complete and gives an integrated approach to this problem.

This is the most agreeable part of the book, due to the friendly reading and the stylist way in which the most of the chapters are written.

4. Phenomenological Models

The third part, "Phenomenological Models", deals with the attempts to reproduce the Critical Infrastructure real behavior. The various methodologies are examined with a special look to the Simulation. The conflicts between urgency of results and time needed to design a good experience, recovering data enough (and its cost) are considered. Also the very difficult problem of modeling the human behavior, so much studied and never solved, is studied.

To deal successfully with the Critical Infrastructures the quality of the models used to reproduce its real behavior is evidently mandatory. This problem approach in this part of the book is quite complete and scrupulous.

It is the "work" part of this book. In fact, the construction of models work requires patience and perseverance: many tries and errors. And, of course, a bit of patience is needed to read it.

5. Mathematical Models

In what concerns the mathematical models presented, very important for this book, to note that many researchers support the use of Mathematics in the complexity study but only easy Mathematics¹. This is not a correct position. About a complex problem nothing or very few is known². So, when using Mathematics, it is not possible to know *a priori* if it is necessary either easy or difficult Mathematics. In this book the Mathematics used is the adequate and there are not unnecessary complications.

The mathematical tools used fall mainly in the scope of Operations Research and Probability and Statistics. They are important in the great amount of models present, being the most of more famous referred and also presented. The Editors point themselves the

¹ Certainly because of the responsibilities in the recent world financial crisis attributed to bankers ignorance in mathematical models, supposedly complicated.

² In the beginning of the book there is a phrase, "Sometimes life is complicated, sometimes is just complex", that resumes perfectly this concept.

absence of I/O Models and some missing of System Risk Analysis and Time Series Analysis. Note also the missing of Queuing Theory and Game Theory.

6. Overall Review

Nowadays life is composed of a lot of networks of networks, or even of only a huge network of networks. From a methodological point of view, the conception of networks of networks is much friendlier in permitting a good analysis than the one of the huge network of networks. In any case always complexity is faced. This justifies the title of this wonderful book edited by Gregorio D'Agostino and Antonio Scala. Although it is always risky to call to anything "the last..." the texts in this book are convincing in stressing this point of view.

The book is composed of three parts: Theoretical Approaches, Applications and Phenomenological Models. In particular, the first part constitutes a general overview on the Networks of Networks (Net O Nets) in particular on the Interdependent Networks that are the ones that really interest. In general, the whole book is devoted to the problems of governing, managing and preserving (with special attention to the security and the resistance to natural catastrophes problems) Networks of Networks.

Along this book, a lot of practical examples of this kind of devices are considered. From this point of view it may be said that it is complete and gives an integrated approach to this problem.

Finally to refer the mathematical models presented. Many researchers support the use of Mathematics in the complexity study but only easy Mathematics. This not a correct position since a complex problem is a one about which nothing or very few is known. So, when using Mathematics, it is not possible to know a priori if it is necessary either easy or difficult Mathematics. In this book the Mathematics used is the adequate and there are not unnecessary complications.

Concluding, this is a very interesting book, very pleasant to read, essential either for beginners in this matter or senior researchers. This book is really a research book, fundamental in the Networks of Networks study, very pleasant to read, essential either for beginners in this matter or senior researchers.

Reference

- [1] G. D'Agostino, A. Scala (Eds.). Networks of Networks: The Last Frontier of Complexity. Series: Understanding Complex Systems, XII, 340 p., 2014. ISBN: 978-3-319-03517-8. DOI: 10.1007/978-3-319-03518-5.