Journal of Statistical Physics, Vol. 122, No. 6, March 2006 (© 2006)
DOI: 10.1007/s10955-006-9060-8

Book Review: *Evolution and Structure of the Internet: A Statistical Physics Approach.*

Evolution and Structure of the Internet: A Statistical Physics Approach. Romualdo Pastor-Satorras and Alessandro Vespignani, Cambridge University Press, Cambride, 2004, 267 pp.

Published Online: March 23, 2006

"Things have always been changing on the Internet, sometimes gradually and sometimes very rapidly, but always evolving without a precise general design." Indeed. My first encounter with the Internet, around 1991, was with the now long-forgotten Gopher, the precursor of the fledging Web. I was overwhelmed by the sheer amount of information I stumbled upon, which in retrospect pales in comparison with any of the bigger portals in existence today. Its popularity and size have been on a constant uphill climb ever since, which explains why two statistical physicists, Romualdo Pastor-Satorras and Alessandro Vespignani, had taken on the task of describing the major influencing trends that shape its development and its present form.

Why another book on the Internet, when excellent works on every conceivable aspect of computer networking theory and practice abound? The approach the authors take is radically different: being important contributors to the field of complex networks, they use this expertise here in tackling various practical problems related to the information superhighway. The concept of complex networks appeared only a couple of years ago, and it draws parallels between seemingly unrelated systems in sociology, biology, or numerous areas of technology. Common in them is that they all consist of microscopic units with interactions, and thus the tools of graph theory can be fruitfully applied for their study. In the case of the Internet the graph is laid out by routers and cables, in society by people and the bonds of acquaintanceship. The particular appeal for a physicist is the large number of analogies that connects this field to other areas of statistical physics, since it is usually the emergent global behavior of the system that we observe, not the dynamics of the individual constituents. Very often, the results the authors present in this book are equally true for many other natural networks.

No doubt, measuring the Internet is a daunting task. After a brief historical review of the early days, this is where the book actually begins and sets the stage for

the rest of it: the analysis would be based on three undirected, unweighted Internet graphs, all obtained around 2000 that give a largely coarse-grained picture of the network, but eventually make the numerical study feasible. The reader is led through the, by now standard, measures of complex networks such as path lengths, node degree distributions and correlations, and the density of triangles. We are shown that they all point towards a scale-free Internet that fits well with our understanding of other natural networks.

The overview of Internet topology models is centered around those developed by the physics community: the powerful evolving preferential attachment model and its variations, fitness and cost-optimization models. Some of these the authors meticulously dissect, but luckily for the uninitiated, the technical details are mostly relegated to the appendices. For completeness and their historical relevance, the Erdös–Rényi random graph and small-world models are also mentioned. There is no need to master more mathematics than basic probability theory, although familiarity with the approximation methods of statistical physics certainly helps. Is the fabric of the Internet fragile or robust? It is both. We get to learn the answer from analogies with percolation, and the authors show their true strength in the chapter about epidemics and virus spreading on scale-free networks, which is an area they have pioneered. While the Internet is just the medium for communication, real applications and services make it interesting. The book covers topics about the structure and modeling of the WWW, peer-to-peer networks, and Web search, to name a few. There is a short chapter on the traffic and global performance of the network, where the authors provide ample references to choose from for the interested. The same is true for the entire book.

The collection of topics in this book is broad, just as the Internet is itself. Despite the fact that it is also comparatively young, a coherent picture starts to emerge that is painted by the authors culling from the relevant literature of the past few years. This makes the book a good point of reference or entry-level introduction to complex networks, and definitely an interesting read.

Gábor Szabó
Department of Physics
University of Notre Dame
Notre Dame, Indiana 46556
E-mail: gabor.szabo@nd.edu