



Chapter VII

Complexity, Information, and Robustness: The Role of Information “Barriers” in Boolean Networks

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Abstract

In this supposed “information age,” a high premium is put on the widespread availability of information. Access to as much information as possible is often cited as key to the making of effective decisions. While it would be foolish to deny the central role that information and its flow has in effective decision-making processes, this chapter explores the equally important role of “barriers” to information flows in the robustness of complex systems. The analysis demonstrates that (for simple Boolean networks at least) a complex system’s ability to filter out (i.e., block) certain information flows is essential if it is not to be beholden to every external signal. The reduction of information is as important as the availability of information.

Introduction

In the information age, the importance of having unfettered access to information is regarded as essential—almost a “right”—in an open society. It is perhaps obvious that acting with the benefit of (appropriate) information to hand results in “better” actions (i.e., actions that are more likely to achieve desired ends), than acting without information (although incidents of “information overload” and “paralysis by (over) analysis” are common). From a complex systems perspective there are a variety of questions/issues concerning information, and its near cousin knowledge, that can be usefully explored. For instance, what is the relationship between information and knowledge? What is the relationship between information, derived knowledge, and objective reality? What information is necessary within a particular context in order to make the “best” choice? How can we distinguish between relevant information and irrelevant information in a given context? Is information regarding the current/past state of a system sufficient to understand its future? Complexity thinking offers new mental apparatus and tools to consider these questions, often leading to understanding that deviates significantly from (but not necessarily exclusive of) the prevailing wisdom of the mechanistic/reductionistic paradigms. These questions may seem rather philosophical in nature, but with a deeper appreciation of the nature of information and the role it plays in complex systems and networks, we can begin to design more effective and efficient systems to facilitate (rather than merely manage) information creation, maintenance, and diffusion.

The science of networks has experienced somewhat of a renaissance in recent years with the discovery of particular network topologies, or architectures, in natural and human systems. These topologies include both small-world (Watts & Strogatz, 1998) and scale-free networks (Barabási & Albert, 1999). Barabási (2001) has shown that the World Wide Web has a scale-free architecture, which essentially means that it has relatively few high-connected nodes (i.e., nodes containing many inputs and outputs) and relatively many low-connected nodes (i.e., nodes containing few inputs and outputs). However, there are significant limitations to network representations of real world complex systems. Barabási (2001) himself says that “The advances [in network theory] represent only the tip of the iceberg. Networks represent the architecture of complexity. But to fully understand complex systems, we need to move beyond this architecture and uncover the laws that govern the underlying dynamical processes, such as Internet traffic...”

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