ECCS'11 Submission 62

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Paper 62 (abstract only)

Title: Comparing Principles of Robustness in Biological and Socio-Technical Systems

Category: Talk

Keywords: complex adaptive systems, biological robustness, emergent engineering, degeneracy, flexibility, socio-technical systems

Topics: Foundations of Complex Systems, From Molecules to Living Systems, Policy, Planning & Infrastructure

Abstract: Robustness is an important property for socio-technological artefacts operating in dynamic and uncertain environments. Although terminologies differ greatly, the mechanisms and principles known to support robustness are surprisingly similar to those observed in biological systems. In this article, we discuss recent developments in understanding biological robustness and we propose important and thus far overlooked principles that could further enhance the robustness of socio-technical systems.

First, we briefly review basic control concepts, heuristics from engineering, and management principles from organization science. Comparing these with systems principles derived from the study of multi-cellular development, protein conformation dynamics, cell signalling, metabolic networks, and gene regulatory networks, we outline surprising similarities in the mechanisms and systems principles that support robustness in biological and socio-technical systems.

However one clear point of distinction is found to arise in the presence/absence of degeneracy; a common facilitator of robustness in biology. Degeneracy is a relational property that describes the presence of structurally dissimilar components/modules/pathways that are each multifunctional and when compared are found to perform similar functions (i.e. are effectively interchangeable) under certain conditions yet perform distinct functions in many others. Here we describe different types of robustness that arise from degeneracy and we propose simple ways that systems of degenerate components can violate classic robustness-efficiency tradeoffs in engineering. We also propose how degeneracy can facilitate pervasive system flexibility through a type of distributed robustness known as networked buffering. Finally, we speculate on how degeneracy might be harnessed in organizations to better deal with crises and unanticipated challenges.

Time: Mar 24, 16:15 GMT

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