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Networked buffering: a basic mechanism for distributed robustness in complex adaptive systems

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(Submitted on 10 Dec 2009)

This paper proposes a generic design principle for generating robust traits in complex systems that requires two basic conditions to be satisfied: 1) agents are versatile enough to perform more than one single functional role within a system and 2) agents are degenerate, i.e. there exists a partial overlap in the functional capabilities of agents. Our principle claim is formulated within the so-called networked buffering hypothesis. It outlines how degenerate systems may readily produce a distributed response to local perturbations and reciprocally how excess resources related to a single function can indirectly support multiple unrelated functions within a degenerate system. The conditions needed to achieve this buffering behavior are not demanding or rare, leading us to speculate that degeneracy may fundamentally underpin the distributed robustness that is prevalent within biological systems. We further argue that degenerate forms of distributed robustness may readily arise in other disciplines. For instance, it may allow for new insights into engineering design and strategic planning activities that occur under high uncertainty. We also speculate that the proposed hypothesis may explain recent breakthroughs in understanding the origins of resilience within complex ecosystems.

Comments: Submitted to Royal Society Interfaces
Subjects: **Adaptation and Self-Organizing Systems (nlin.AO)**
Cite as: **arXiv:0912.1961v1 [nlin.AO]**

Submission history

From: James Whitacre [view email]
[v1] Thu, 10 Dec 2009 10:53:04 GMT (158kb)

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