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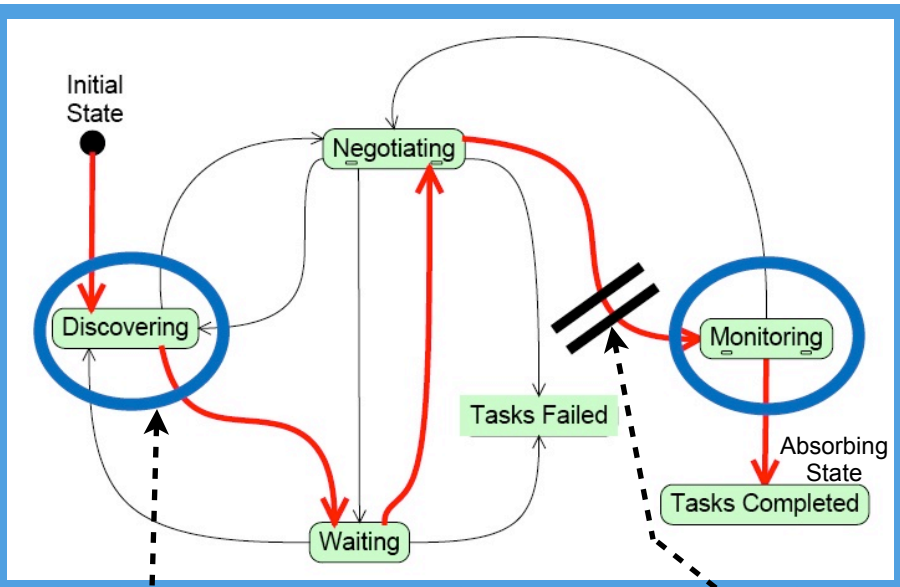
complex systems February

IMAGE OF THE MONTH

Improving the Efficiency of Markov Chain Analysis



In this new approach, we use graph theory concepts to identify states and state transitions in Markov chain graphs where perturbation of transition probabilities produces drastic changes in system behavior. This approach exhibits as good or better success ratio as the earlier perturbation algorithm reported in [Jan 09 IOM], but with an additional reduction in computing costs of 1-2 orders of magnitude.

Graph is effectively disconnected at this point by raising probability of staying in the Discovering state to 1

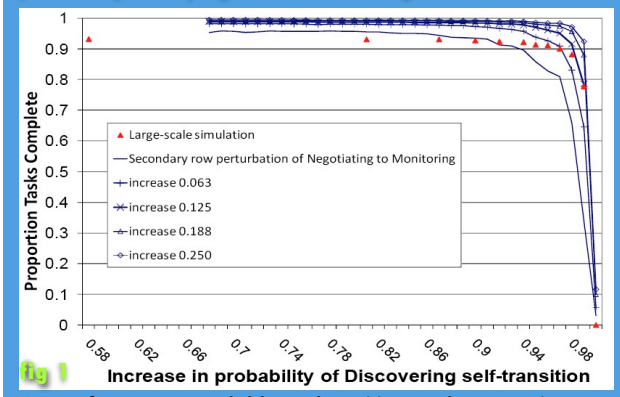


fig 1

Graph is effectively disconnected at this point by lowering probability of transition of Negotiating –> Monitoring to 0

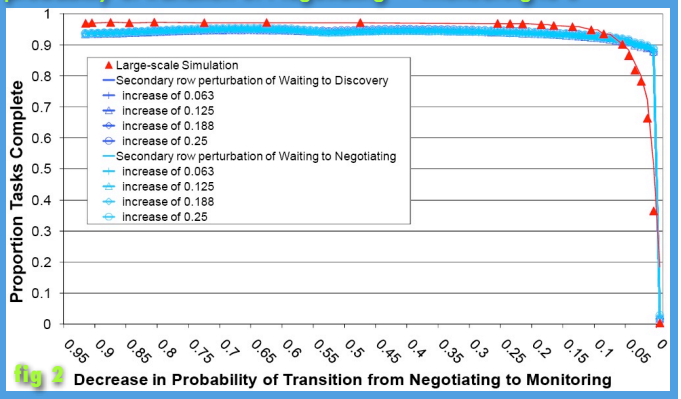


fig 2

More information available at: http://www.itl.nist.gov/ITLPrograms/ComplexSystems/Papers.html

In this simple example, the Markov chain can be represented as a directed graph with two paths (shown in red) from the Initial State to the absorbing state, Tasks Completed. If individual states, such as Discovering or Monitoring (circled) or individual state transitions corresponding to edges in a graph, such as Negotiating to Monitoring, are removed, then both paths to the absorbing states are cut. In graph theory, a set of edges in a graph, which if removed, would disconnect all paths between two vertices (or points), s and t, is referred to as an s-t cut set.

States and state transitions whose removal disconnects all paths between the Initial state and Tasks Completed can predict where perturbation is most likely to drastically change system performance, as figures 1 & 2 show.

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The Complex Systems Program is part of the National Institute of Standards and Technology's Information Technology Laboratory. Complex Systems are composed of large interrelated, interacting entities which taken together, exhibit macroscopic behavior which is not predictable by examination of the individual entities. The Complex Systems program seeks to understand the fundamental science of these systems and develop rigorous descriptions (analytic, statistical, or semantic) that enable prediction and control of their behavior.

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