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Network Reliability Models

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Many systems - such as power plants, communication and transportation networks, nuclear reactors, bridges, dams, and so on - can be modeled as networks of nodes and edges. Whether the system performs satisfactorily will then depend on the states - either working or failed - of these component entities. A problem of importance is to determine the expected level of the system under situations such as a terrorist attack or a catastrophic environmental event.

The difficulty in the analysis of a network system of the preceding type resides in the fact that the number of possible state vectors of the system is 2 raised to the power equal to the number of components, which makes it computationally difficult to determine the exact value of the expected system performance level. In addition, because there are many possible probabilistic assumptions about the component's probabilities of working after an attack, we need a method of analysis that is both accurate and fast. Because a pure analytic approach is not computationally feasible it is natural to consider a simulation approach.

Whereas almost all previous simulation approaches have been concerned with systems in which the component states are assumed to be independent, we developed an efficient simulation approach that can be employed even when there are dependencies. In the paper [1] we presented a new approach, based on an improved use of standard stratified sampling, for using simulation to estimate the expected system performance level. This is accomplished first when the vector of component states has a joint distribution that is exchangeable and secondly when there is a random environmental parameter such that individual components working probabilities are linear functions of the value of this parameter. Thus, while other papers in the literature have all assumed that the components are independent our method allows for dependencies depending on the severity of the attack. Moreover, even when the components are independent our method appears to be more efficient than others in the literature.

[1] Ross, Sheldon, ``A New Simulation Approach to Estimating Expected Values of Functions of Bernoulli Random Variables under Certain Types of Dependencies", accepted for publication in IIE Transactions.

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