

# Environmental Diversity Techniques of Software Systems

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Several recent studies have reported that most outages in technical computer-based systems are due to software faults. Traditional methods in software engineering are fault avoidance/removal based on extensive testing/debugging, and fault tolerance based on design/data diversity. Since both of them are very expensive and unrealistic in common cases, the key challenge is how to provide highly dependable software with relatively cheaper cost. We introduce several environmental diversity techniques of software systems, and overview the typical examples involving checkpoint restart and software rejuvenation. Based on the author's own research results during a past decade, we discuss stochastic models to derive several checkpoint restart and software rejuvenation policies analytically in terms of the optimality under cost criteria.

First, we formulate the checkpoint placement problems [1,14,16,17], which can be characterized by optimization problems to derive the checkpoint sequence. Second, we introduce the concept of software aging and rejuvenation, and summarize several stochastic models to determine the optimal software rejuvenation policies [2,3,4,5,7,8,9,10,11,12,13,14,15,18,19]. Third, we concern intrusion tolerant systems and consider some control policies to improve the system availability and its related measures [6,20,21,22]. Finally, the present research trend and the open problems in future are also discussed.

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