Software Fault Tolerance via Environmental Diversity

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Abstract

Complex systems in different domains contain significant amount of software. Several recent studies have established that a significant fraction of system outages are due to software faults. Traditional methods of fault avoidance, fault removal based on extensive testing/debugging, and fault tolerance based on design/data diversity are found wanting. The key challenge then is how to provide highly dependable software. We discuss a new view of fault tolerance of software-based systems. We classify software faults into *Bohrbugs* and *Mandelbugs*, and identify aging-related bugs as a subtype of the latter. Traditional methods have been designed to deal with Bohrbugs. The next challenge then is to develop mitigation methods for Mandelbugs in general and *aging-related bugs* in particular. We submit that mitigation methods for Mandelbugs utilize *environmental diversity*. Retry operation, restart application, failover to an identical replica (hot, warm or cold) and reboot the OS are examples of mitigation techniques that rely on environmental diversity. For *software aging* related bugs it is also possible to utilize proactive environmental diversity technique known as *software rejuvenation*. We discuss environmental diversity both from experimental and analytic points of view and cite examples of real systems employing these techniques.

Short Biography

Kishor S. Trivedi holds the Hudson Chair in the Department of Electrical and Computer Engineering at Duke University, Durham, NC. He has a B.Tech (EE, 1968) from IIT Mumbai, M.S. (CS, 1972) and PhD (CS, 1974) from the University of Illinois, Urbana-Champaign. He has been on the Duke faculty since 1975. Since 2018, he has been a Specially Appointed Professor in the School of Informatics and Data Science and Hiroshima University in Hiroshima, Japan. He is the author of a well-known text entitled, Probability and Statistics with Reliability, Queuing and Computer Science Applications, first published by Prentice-Hall; a thoroughly revised second edition (including its Indian edition) of this book has been published by John Wiley. He is a Life Fellow of the Institute of Electrical and Electronics Engineers. He is a Golden Core Member of IEEE Computer Society. He has published over 600 articles and has supervised 48 Ph.D. dissertations. He is the recipient of IEEE Computer Society Technical Achievement Award for his research on Software Aging and Rejuvenation. His research interests in are in reliability, availability, performance, performability and survivability modeling of computer and communication systems. He works closely with industry in carrying our reliability/availability analysis, providing short courses on reliability, availability, performability modeling and in the development and dissemination of software packages such as SHARPE and SPNP. His URL is www.ee.duke.edu/~ktrivedi