

# Preface

This book focuses on reliability modeling of complex multichannel systems, a well-known example of which are digital fly-by-wire aircraft control systems. Since the consequences of failure of these systems are severe, having both substantial economic and personnel safety implications, it is of critical importance that the analysis of these systems be done correctly. With the current widespread use of this type of system (even automotive “drive-by-wire” systems are now being seriously considered), correct assessment of the reliability of such systems has become increasingly important. Not only is a correct reliability model crucial for understanding the system once it is fully designed, but it also serves as a critically important tool in the assessment of the myriad design alternatives that are considered during the design phase.

Despite the importance of correctly modeling these complex multichannel systems, there is a paucity of literature addressing the topic; this is especially true of the reliability assessment of redundant systems that use voting-based selectors that may be subject to imperfect fault coverage. All redundant systems must have some means of selection among their redundant inputs, a task that has been termed *redundancy management* (in the aerospace vernacular, at least). Redundancy management can seldom, if ever, be done with perfect certainty, and therefore, redundant systems are subject to imperfect fault coverage. Imperfect fault coverage has a significant adverse impact on the reliability of redundant systems (as compared with systems that have perfect fault coverage) and, as a result, cannot properly be ignored in the assessment of complex multichannel system reliability.

Even basic complex system reliability modeling (with perfect fault coverage) is intrinsically difficult, and it is a well-known example of an NP-complete problem. The correct modeling of redundant systems, when accounting for the effects of imperfect fault coverage, requires the use of powerful analysis tools. Historically, the analysis of multichannel system reliability that accounts for voting-based imperfect fault coverage required the development of very complex conditional probability models. These models were difficult and tedious to construct and, because of this difficulty, required a great deal of additional effort to validate. Consequently, they

tended to play a limited role in the initial design phases of a system and were primarily used only to assess the reliability of the final product.

Analysis techniques and tools now exist to correctly assess complex multichannel systems both quickly and accurately; these techniques and tools are fully explained and their use demonstrated in this book. The techniques discussed here include the use of binary decision diagrams (BDD) and BDD-based algorithms for the reliability assessment of redundant systems subject to imperfect fault coverage. The objective of this book is to provide a set of basic analytical and numerical techniques that are suitable for modeling these systems. The approach of the book is to concentrate on the demonstration of these techniques, rather than on the development and derivation of their underlying theoretical basis.

This book provides the necessary background for an engineer to develop valid reliability models for large, complex redundant systems, including those subject to imperfect fault coverage.

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