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Binary Decision Diagram Reliability for Multiple Robot Complex System

Hamed Fazlollahtabar
Sharif University of Technology, Iran & National Elites Foundation, Iran

Seyed Taghi Akhavan Niaki
Sharif University of Technology, Iran

INTRODUCTION

Generally, complex systems in reliability are defined as a system having a combination of series, parallel, R out of N and standby components. Each of these models has the corresponding mathematical formulations for reliability computations leading to decompose the original system (or sub-system) into an equivalent one with a known cumulative distribution function (CDF) or reliability function. Continuing the decomposition procedure enables the decision maker to reduce the whole system to a unique component with a known CDF. For better understanding, an illustrative example for a complex system reduction is given in Figure 1. The system is composed of both series and parallel components which are reduced first to a series system and eventually to a one-component system.

It should be noted that the reduction methods explained before are not effective for all systems. In cases with complicated interrelations of components it is required to develop an efficient methodology. This methodology deals with subjects such as event trees, Boolean representations, coherent structures, cut sets and decompositions.

Network reliability analysis receives considerable attention for the design, validation, and maintenance of many real world systems, such as production, computer, communication, or power networks. The components of a network are subject to random failures, as more and more enterprises become dependent upon network or networked computing applications. Failure of a single component may directly affect the functioning of a network. So the failure probability of each component is a crucial consideration while considering the reliability of a network. There are so many exact methods for computation of network reliability (Bobbio et al., 2006). The network model is a directed stochastic graph $G=(V, E)$, where V is the vertex set, and E is the set of directed edges. An incidence relation associates with each edge of G a pair of nodes of G, called its end vertices. The edges represent components that can fail with known probability. In real problems, these probabilities are usually computed from statistical data. The problem related with connection function is NP-hard. The same thing is observed for planar graphs (Provan, 1986).

BACKGROUND

The word *reliability* can be traced back to 1816, by poet Coleridge before World War II the name has been linked mostly to repeatability (Saleh and Marais, 2006). A test (in any type of science) was considered reliable if the same results would be obtained repeatedly. In the 1920s product improvement through the use of statistical process control was promoted by Dr. Walter A. Shewart at Bell Labs. Around this time Wallodi Weibull was working on statistical models for fatigue. The

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development of reliability engineering was here on a parallel path with quality (Juran and Gryna, 1988). The modern use of the word *reliability* was defined by the U.S. military in the 1940s and evolved to the present. It initially came to mean that a product would operate when expected (nowadays called "mission readiness") and for a specified period of time. In the time around the WWII and later, many reliability issues were due to inherent unreliability of electronics and to fatigue issues. In 1945, M.A. Miner published the seminal paper titled "Cumulative Damage in Fatigue" in an ASME journal. A main application for reliability engineering in the military was for the vacuum tube as used in radar systems and other electronics, for which reliability has proved to be very problematic and costly. The IEEE formed the Reliability Society in 1948. In 1950, on the military side, a group called the Advisory Group on the Reliability of Electronic Equipment, AGREE, was born. This group recommended the following 3 main ways of working:

- Improve Component Reliability;
- Establish quality and reliability requirements (also) for suppliers;
- Collect field data and find root causes of failures.

In the 1960s more emphasis was given to reliability testing on component and system level. The famous military standard 781 was created at that time. Around this period also the much-used (and also much-debated) military handbook 217 was published by Radio Corporation of America (RCA) and was used for the prediction of failure rates of components. The emphasis on component reliability and empirical research (e.g. Mil Std 217) alone slowly decreases. More pragmatic approaches, as used in the consumer industries,

Figure 1. A complex system reliability