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Network Reliability

A Lecture Course

Springer

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Preface

The reader interested in learning about network reliability may read these lectures in two ways—as a short or as a full course.

In the first case, he/she starts with Chap. 2 which gives a formal definition of a network and describes various ways of defining network reliability. Then goes Chap. 3 which describes elementary methods of calculating network reliability. Next Chap. 4 describes a universal and rather simple working tool—so-called crude Monte Carlo. This method is not the best one but can work in any situation. Chapter 4 presents also a typical pseudocode for a Monte Carlo computer program. The short course is concluded by Chap. 5, which describes applications of theoretical material about component importance. Chapters 2–5 already enable to solve, perhaps in a nonoptimal way, a wide range of network reliability problems. The reader can also look through Chap. 8 if she/he is interested in some new applications of network reliability theory to practical problems.

For a full course, the reader starts with Chap. 1 and goes through all other chapters.

The contents of these lectures correspond to Network Reliability course delivered in Sami Shamoon Engineering College (Beer-Sheva, Israel) for M.Sc. students specializing in software engineering. It was delivered in 2013–2018 years as 1-semester course, 4 hours weekly. The prerequisites are elementary probability theory and computer programming.

We strongly recommend to the lecturers of this course to include in the final mark also the results of two–three homeworks devoted to network simulation and reliability analysis.

We tried to write these lectures in a simple and reader-friendly way. We avoided complex proofs and tried, wherever possible, to rely on intuition and explain formal statements by numerical examples.

George Box used to cite the aphorism: “all models are wrong; some models are useful.” We hope that some models presented in this book might be useful to reliability researchers involved in network study and design and to reliability engineers interested in applications of the theory to practical calculations of network reliability parameters.

Beer-Sheva, Israel Ilya Gertsbakh
September 2019 Yoseph Shpungin

Contents

Notations and Abbreviations

up, *down*	Element states in the system (in the network)
network element	Edge or node of the network subject to failure
UP, *DOWN*	States of the network
c.d.f., CDF	Cumulative distribution function
τ, X, Y, Z	Random variables (r.v.s.)
CD-spectrum	Cumulative destruction spectrum
D-spectrum	Destruction spectrum
$X \sim \text{Exp}(\lambda)$	r.v. X is exponentially distributed with parameter λ
r.e., rel.err.	Relative error
$\mathcal{N} = (V, E, T)$	Network with node (vertex) set V, edge (link) set E and terminal set T
p, q	Probability that an element is in state *up* and *down*, respectively
$\mathbf{x} = (x_1, x_2, \ldots, x_n)$	System (network) state vector; $x_i = 1$, or $x_i = 0$ if element i is *up* or *down*, respectively
$C(x)$	Number of system failure sets with x elements *down*
$Y \sim \mathbf{B}(n, p)$	r.v. Y has binomial distribution
$R(p_1, \ldots, p_n)$	Network reliability as a function of elements reliability
BIM	Birnbaum importance measure
BIM_j	Birnbaum importance measure of element j