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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 Shamon 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
September 2019

Ilya Gertsbakh
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Contents

1	Probability-Reminder	1
1.1	Algebra of Events	1
1.2	Random Variables	2
1.3	The Law of Total Probability	6
1.4	Order Statistics	6
1.5	Average, Variance	8
	References	9
2	Networks and Examples	11
2.1	Nodes, Edges, Terminals	11
2.2	Series-Parallel Networks	17
	References	19
3	Direct Network Reliability Calculation	21
3.1	Static Reliability and Structure Function	21
3.2	Counting Paths and Cuts	25
3.3	Using Inclusion/Exclusion Formula	27
3.4	Pivotal Formula	29
3.5	Burtin-Pittel Approximation	29
3.6	Network Resilience	31
3.7	Static and Dynamic Reliability	33
	References	34
4	Elementary Methods for Reliability Evaluation	35
4.1	Exact Method for Computing Network Reliability	35
4.2	Crude Monte Carlo (CMC)	37
4.3	Relative Error of CMC	39
4.4	CMC for Network Dynamic Reliability Evaluation	41
4.5	Checking Network State	42
	References	47

5	Element Importance	49
5.1	Birnbaum Importance Measure (BIM)	49
5.2	Direct Computation of BIM	50
5.3	Monte Carlo for Computing BIM	54
	References	56
6	Destruction Monte Carlo	57
6.1	Individual and Comparative Network Reliability Analysis	57
6.2	Network Destruction	59
6.3	BIM Spectrum	63
6.4	CD-Spectrum and BIM Spectra Monte Carlo	65
	References	69
7	Lomonosov's Turnip	71
7.1	Evolution Process	71
7.2	Lomonosov's Algorithm	74
7.3	Turnip for Networks with Unreliable Nodes	76
7.4	Convolution of Exponents	79
	References	80
8	Examples of Network Analysis	81
8.1	Network Structure and Resilience Against Node Attack	81
8.2	Road/Highway Reinforcement	84
8.3	Flow in Network with Unreliable Edges	87
	References	90

Notations and Abbreviations

<i>up, down</i>	Element states in the system (in the network)
<i>network element</i>	Edge or node of the network subject to failure
<i>UP, DOWN</i>	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 <i>up</i> and <i>down</i> , respectively
$\mathbf{x} = (x_1, x_2, \dots, x_n)$	System (network) state vector; $x_i = 1$, or $x_i = 0$ if element i is <i>up</i> or <i>down</i> , respectively
$C(x)$	Number of system failure sets with x elements <i>down</i>
$Y \sim \mathbf{B}(n, p)$	r.v. Y has binomial distribution
$R(p_1, \dots, p_n)$	Network reliability as a function of elements reliability
BIM	Birnbaum importance measure
BIM_j	Birnbaum importance measure of element j