# Contents

## Part I Network Structure

**Tomography and Stability of Complex Networks**  
*Tomer Kalisky, Reuven Cohen, Daniel ben-Avraham, Shlomo Havlin*  

1. Introduction ................................................. 3  
2. General Results ............................................. 4  
3. Scale-Free Networks ........................................... 8  
4. Tomography of Scale Free Networks ....................... 11  
5. Random Breakdown .......................................... 18  
6. Intentional Attack ............................................ 19  
7. Critical Exponents .......................................... 23  
8. Conclusions .................................................. 31

**Spectral Analysis of Random Networks**  
*Sergei N. Dorogovtsev, Alexander V. Goltsev, José F.F. Mendes, Alexander N. Samukhin*  

1. Introduction ................................................... 35  
2. Random Walk on a Tree ...................................... 36  
3. General Theory ................................................ 37  
4. Spectra of Uncorrelated Graphs ............................. 39  
5. Effective Medium Approximation ............................. 40  
6. Tail Behavior and Finite-Size Effects ..................... 40  
7. Spectrum of a Transition Matrix ............................ 42  
8. Spectra of Different Topological Graphs .................. 43  
9. Conclusions .................................................. 48

**A Tractable Complex Network Model**  
*Based on the Stochastic Mean-Field Model of Distance*  
*David J. Aldous*  

1. Introduction ................................................... 51  
2. Formulas ...................................................... 53  
3. The Model ..................................................... 59  
4. Calculations .................................................. 67  
5. Further Calculations ........................................ 77  
6. Comparison with Other Models .............................. 84
## The Small World Phenomenon in Hybrid Power Law Graphs

*Fan Chung, Linyuan Lu*

1. Introduction ................................................... 89
2. Preliminaries .................................................... 91
3. Local Graphs .................................................... 93
4. The Hybrid Power Law Model .................................. 95
5. Several Facts Concerning Random Power Law Graphs .... 97
6. The Diameter of the Hybrid Model ..................... 99
7. Concluding Remarks ........................................... 101

## Classes of the Shortest Pathway Structures in Scale Free Networks

*Kwang-Il Goh, Eulsik Oh, Chul-Min Ghim, Byungnam Kahng, Doochul Kim*

1. Introduction ................................................... 105
2. Load or Betweenness Centrality .......................... 107
3. Load-Load Correlation ........................................ 115
4. Diameter Change Distribution ............................... 118
5. Conclusions and Discussion ............................... 123

## The Optimal Path in an Erdős-Rényi Random Graph

*Lidia A. Braunstein, Sergey V. Buldyrev, Sameet Sreenivasan, Reuven Cohen, Shlomo Havlin, H. Eugene Stanley*

1. Introduction ................................................... 127
2. Theoretical Arguments ....................................... 128
3. Numerical Analysis ........................................... 129
4. Probability Distribution of the Maximal Weight on the Optimal Path .......................... 132

## Clustering in Complex Networks

*Gábor Szabó, Mikko Alava, János Kertész*

1. Introduction ................................................... 139
2. Examples of Clustering ........................................ 141
3. Models That Create Clustering .............................. 143
4. Rate-Equation Approach ..................................... 151
5. Conclusions ................................................... 159

## Equilibrium Statistical Mechanics of Network Structures

*Illes Farkas, Imre Derényi, Gergely Palla, Tamás Vicsek*

1. Introduction ................................................... 163
2. Preliminaries .................................................... 165
3. Graph Ensembles .............................................. 166
4. Main Features of Equilibrium Graphs: Local and Global Properties .......................... 176
5. Topological Phase Transitions in Equilibrium Network Ensembles .......................... 178
6. Summary ....................................................... 184
Attacks and Cascades in Complex Networks
Ying-Cheng Lai, Adilson E. Motter, Takashi Nishikawa

1 Introduction ................................................... 299
2 Conceptual Network of Language ................................. 301
3 Attack-Induced Cascades in Complex Networks .................... 302
4 Range-Based Attacks on Links in Complex Networks ............... 305
5 Discussion ..................................................... 308

Part III Information Networks & Social Networks

Scholarly Information Network
Paul Ginsparg .................................................... 313
1 arXiv Background and Lessons ................................... 313
2 New Scholarly Publication Models ................................. 318
3 Novel Corpus Navigation Tools ................................... 322
4 Text Classification and Support Vector Machines ................. 326
5 arXiv q-bio Extraction ........................................... 329
6 Conclusion ..................................................... 334

Who Is the Best Connected Scientist?
A Study of Scientific Coauthorship Networks
Mark E.J. Newman ............................................... 337
1 Introduction ................................................... 337
2 Coauthorship Networks ......................................... 339
3 Basic Results .................................................. 341
4 Distances and Centrality ........................................ 352
5 Weighted Collaboration Networks ................................ 361
6 Conclusions .................................................... 366

Information Dynamics in the Networked World
Bernardo A. Huberman, Lada A. Adamic ......................... 371
1 Introduction ................................................... 371
2 Email as Spectroscopy ......................................... 372
3 Information Flow in Social Groups ................................ 379
4 Small World Search ........................................... 386
5 Conclusion ..................................................... 395

Emergence of Complexity in Financial Networks
Guido Caldarelli, Stefano Battiston, Diego Garlaschelli,
Michele Catanzaro ................................................. 399
1 Introduction ................................................... 399
2 The Board and Director Networks ................................ 400
3 Network of Price Correlations ................................... 406
4 The Stock Investment Network .................................... 412
Topology, Hierarchy, and Correlations in Internet Graphs
Romualdo Pastor-Satorras, Alexei Vázquez, Alessandro Vespignani ........ 425
1 Introduction ................................................... 425
2 Internet Maps .................................................. 427
3 Average Properties ............................................. 428
4 Scale-Free Properties ........................................... 430
5 Hierarchy and Correlations ...................................... 434
6 Conclusions .................................................... 438

Part IV Biological Networks

Characteristics of Biological Networks
Albert-László Barabási, Zoltán N. Oltvai, Stefan Wuchty ................. 443
1 Introduction ................................................... 443
2 Basic Network Features ......................................... 444
3 Network Models ................................................ 445
4 Conclusions .................................................... 453

Boolean Modeling of Genetic Regulatory Networks
Réka Albert ....................................................... 459
1 Introduction ................................................... 459
2 The Segment Polarity Gene Network ................................ 463
3 Description of the Model ....................................... 465
4 Modeling the Wild Type Segment Polarity Genes ................. 467
5 The Functional Topology of the Segment Polarity Network .... 469
6 Gene Mutations ................................................ 472
7 Determination of the Steady States and Their Domains of Attraction ........................................ 473
8 Possible Changes in the Assumptions .............................. 476
9 Conclusions .................................................... 479

Theoretical Neuroanatomy: Analyzing the Structure, Dynamics, and Function of Neuronal Networks
Anil K. Seth, Gerald M. Edelman .................................. 483
1 Introduction ................................................... 483
2 Structure ....................................................... 484
3 Dynamics ....................................................... 488
4 Function ....................................................... 493
5 General Discussion ........................................... 504
Appendix A: Implementation Details .................................. 506

Index ............................................................ 513