

Index

- 19 degrees of separation 93
 80/20 rule 116
- accelerated growth 220–1
 accuracy 352–5
 Achilles' Heel 16, 272, 302–5
 acquaintance network 46
 actor network 56
 actors 11, 26
 adjacency matrix 51–2
 agglomerative algorithms 331
 air transportation network 398
 Akamai 29
 Albert, Réka 7
 algorithm 254
 algorithm (CFinder) 348
 algorithmic complexity 356
 Apple 29
 Asimov, Isaac 7
 assortative 253–6
 assortative mating 259
 assortative network 236, 256
 Attack 15, 284
 attack tolerance 284–6
 avalanche exponents 288
 average cluster similarity 332
 average clustering coefficient 70
 average degree 47–51
 average path length 59–61
 average-linkage clustering 333
- BA Model 169–70
 Ball, Philipp 4
 Barabási-Albert Model 12, 169–70, 196, 215, 280
- Baran, Paul 287
 Bell number 329
 Berners-Lee, Tim 5, 167
 Bianconi-Barabási Model 204–7, 216, 226, 253
 bigraph 54
 binomial distribution 78–80
 biochemical networks 26
 bipartite graph 54
 Black Death 389
 blackout 21, 288–90
 Bollobás, Béla 3, 16
 bond percolation 433–5
 Boolean logic 2
 Bose Gas 212, 214
 Bose statistics 212
 Bose-Einstein Condensation 211–16
 brain 32
 brain research 27
 branching model 295–7
 Breadth-first-search (BFS) algorithm 59, 61–2
 breakdown thresholds 283–4
 bridge 63
 Brockman, Jay 11
- C. elegans* 27, 33
 cascade 289
 cascading failures 22, 288, 299
 Cayley tree 101
 cellular network 3, 24
 centrality 334
 centrality measure 334
 CFinder 346, 356
 characteristic time 384
- Cisco 29
 citation patterns 36
 citations 47, 209
 clique 53, 325
 clique percolation 346–9, 357
 clustering coefficient 63, 93–6, 100, 189–90
 clusters 61
 communication networks 24
 community 37, 322, 404–5
 community evolution 357, 359–60
 community size distribution 357–8
 community structure 17
 compartmentalization 381
 compartments 382
 complete graph 53
 complete subgraph 325
 complete-linkage clustering 333
 complex contagion 405–7
 complex systems 23
 component size 106–8
 component 61, 63
 computational complexity 342, 348–9, 356
 computer virus 380
 configuration model 138–9, 226, 251
 connected 61
 connected triplet 70
 connectedness 61–3
 connectedness hypothesis 325
 Connectome 33
 contact networks 396–401, 409
 contagion 419
 contagious 380
 continuum formalism 118–19

- copying model 184–5
 crawler 113
 critical exponents 275
 critical point 110
 cumulative preferential attachment function 179

 de Sola Pool, Ithiel 8, 92
 degree 47–51
 degree correlation coefficient 241
 degree correlation matrix 237
 degree correlations 235, 237, 243, 253–6, 259, 403–4
 degree distribution 10, 17, 47–51, 78–80, 82, 100, 193–6, 206–7, 401–7
 degree sequence 140
 degree-block approximation 390
 degree-preserving randomization 139, 141, 245
 dendrogram 332–3
 density function 428
 density hypothesis 325–6
 diameter 189–90
 digraph 45
 directed 45
 directed network 51–2
 disassortative 253–6
 disassortative mixing 259
 disassortative network 237, 256
 disconnected 61
 disconnected components 63
 discrete formalism 117–18
 disease-free state 386–7
 divisive algorithms 331
 domino effect 288
 Dorogovtsev, Sergey 16
 Doyle, John 16
 drug development 30

 Ebola 32
 edges 45
 electric power 22
 email network 46
 endemic state 385
 enhanced robustness 282, 297
 epidemic equation 426–7
 epidemic forecasts 422
 epidemic modeling 32
 epidemic threshold 37, 393–6, 409, 427–8
 epidemics 32

 Erdős, Paul and Rényi, Alfréd 3, 8, 10, 25, 75, 77, 88
 Erdős-Rényi Model 84, 89, 99–100, 251
 Erdős-Rényi network 75, 101
 errors and failures 271
 Euler, Leonard 43–4
 event time 174
 evolution of a random network 83–7
 evolving network model 226–7
 evolving networks 215–23
 exponential algorithm 330
 external degree 326

 Facebook 29, 94
 failure propagation model 293–4
 failures 15
 fat-tailed distribution 147–8
 Fermi gas 214
 financial meltdown 22
 financial systems 22
 finite size scaling 93
 first-mover advantage 173, 203
 fitness 204, 206
 fitness distribution 205
 fitness model 204
 flavor network 58
 forest fires 278
 friendship network 46
 fully connected regime 108–9
 fundamental hypothesis 324

 $G(N, L)$ Model 75
 generative models 226
 genes 29
 giant component 10, 84, 105–6, 110, 256–7
 Gilbert, Edgar Nelson 77
 Girvan-Newman (GN) Benchmark 352
 Girvan-Newman algorithm 335
 global clustering coefficient 64, 69
 Google 5
 Granovetter, Mark 25
 graph bisection 327
 graph theory 8, 28
 greedy algorithm 341–2
 greedy modularity 355
 group similarity 332
 growth 12, 169
 Guare, John 8, 94

 H1N1 pandemic 32
 Havlin, Shlomo 17
 heterogenous networks 410–11
 hidden-parameter model 139–42, 226
 hierarchical network model 336
 hierarchical clustering 331
 hierarchical model 336
 hierarchical modularity 365–9
 hierarchy 67
 high-degree cutoff 155
 Hollywood actor database 11
 Hollywood actor network 46, 56
 homogenous mixing 382–3
 hub immunization 411, 432
 hub-and-spoke network 297
 hub-and-spoke topology 215
 hubs 10–11
 Huffman coding 373
 Human Disease Network 56

 IBM 1, 3, 11
 immune 382
 immunity 387
 immunization 407–14
 incoming degree 48
 in-degree 116
 infectious 382
 infectious diseases 380
 influenza 32
 infomap 357, 371, 373–5
 information cascades 289–90
 information diffusion 405
 initial attractiveness 215–17
 interdisciplinary 27–8
 internal degree 326
 internal links 218
 Internet 3, 46, 287
 invasion percolation 2

 Jeong, Hawoong 6, 9, 114

 Karinthy, Frigyes 94
 Kaufmann, Stuart 3
 Kerningham-Lin algorithm 328
 Kochen, Manfred 8, 92
 Königsberg 44
 Königsberg graph 44
 Kruskal algorithm 2

 Lancichinetti-Fortunato-Radicchi (LFR) Benchmark 352–3

- Lazarus effect 299
 limits of modularity 342–6
 linearized chord diagram (LCD) 171
 link betweenness 334
 link clustering 349–51, 357
 link communities 350
 link removal 283
 link weights 357–8, 404–5
 link-clustering algorithm 361
 LinkedIn 29
 links 45
 link-selection model 183–4
 local mechanisms 183
 log-normal 148–51
 log-normal (Galton or Gibrat)
 distribution 149
 Louvain 355
 Louvain algorithm 371
 Louvain method 356
 low-degree saturation 155
- management 33
 Mandelbrot, Benoit 189
 map equation 373
 mass-action approximation 382
 maximal modularity 341
 measuring accuracy 353–5
 measuring fitness 208–11
 measuring preferential attachment
 178–80
 Mendes, José 16
 metabolic network 45
 Metcalfe, Robert M 55
 Metcalfe's law 55
 Milgram experiment 92
 Milgram, Stanley 8, 94
 minimum and maximum degree 104
 mobile call graph 46
 mobile call network 361
 mobile phone networks 405
 modularity 339–40, 369–70
 modularity maxima 344
 Molloy-Reed criterion 279–80, 309–10
 movie network 56
 multi-links 139, 171
 mutual information 354
- natural cutoff 121
 nested communities 335
 NetSci 36
 network biology 30
 network diameter 59
 network epidemics 380, 388–96
 network pharmacology 30
 neural network 24
 neurons 32
 neuroscience 32–3
 neutral network 236
 node deletion 219–20
 nodes 45
 nonlinear preferential attachment
 180–2
 NP-complete 330
 NP-completeness 2, 258, 330
 number of partitions 329
- obesity 407
 Oltvai, Zoltán 18
 opinion leaders 33
 optimization model 186, 188
 organizational networks 33
 out-degree 116
 outgoing degree 48
 overlapping communities 346–51
 overload model 297
- Pareto, Vilfredo 116
 Pastor-Satorras, Romualdo 17, 37, 389
 path 56
 path length 56
 pathogens 380, 383
 Patient Zero 380, 398
 percolating cluster 274
 percolation theory 273, 278
 percolation threshold 10
 phase transitions 109–10, 256, 274
 plague 389
 plotting power laws 152–5
 poisson distribution 79–80
 polynomial-time algorithms 330
 power grid 11, 22, 24
 power law 10–11, 16, 110, 115–19
 power law with exponential cutoff 148
 preferential attachment 12, 169
 professional network 46
 projection 56
 protein interaction network 64, 66
- radio-frequency identification devices
 399
 random-walk betweenness 334
 random graph 75
 random hypothesis 338–9
 random immunization 409–11, 413
 random network 75, 93, 97, 110, 226,
 409
 random network model 74
 Rapoport, Anatol 77
 ratio of transitive triplets 70
 Ravasz 355
 Ravasz algorithm 324, 331–2, 350, 353,
 357
 recovered 382
 Redner, Sid 16
 redundancy 303
 reference network 46
 regular lattice 97
 resilience 303
 resolution limit 342–4
 RFID 399
 rich-gets-richer phenomenon 170
 rich-gets-richer process 181, 215
 Riordan, Oliver 17
 robot 10
 robust networks 297–300
 robustness 17, 271, 303
- sandpile model 297–300
 scale-free 117
 scale-free model 169
 scale-free networks 13, 36, 51, 115–19
 scale-free property 16–17, 336
 science collaboration network 46
 scientific collaboration networks 26
 Seldon, Harry 7
 selective immunization 413
 self-loops 65, 139, 171
 sexual hubs 398
 sexual network 46
 Shannon entropy 354
 Shiota, Chiharu 0
 shortest path 59
 SI model 384, 390–3, 428
 similarity matrix 331
 Simon, Herbert 189
 simple contagion 406
 simple networks 240
 single-linking clustering 333
 SIR model 387, 428, 433
 SIS model 385, 393, 409, 428
 six degrees of separation 8, 89–90, 92,
 94
 six degrees 17, 90

- small worlds 8, 89–93
 small-world model 97
 small-world networks 9
 small-world phenomenon 89, 94, 100
 small-world property 90, 143
 snobbish network 102
 social network 8, 24
 Solomonoff, Ray 77
 source of a pandemic 423
 spanning-tree 2
 spread of viruses 32
 spreading rate 393
 Stanley, Gene 13
 static models 226
 statistical physics 28
 stretched exponential 148–51
 stretched exponential (Weibull)
 distribution 148
 Strogatz, Steven 97
 strong community 326
 structural cutoff 243, 267–8
 structural disassortativity 243
 subcritical regime 85
 sublinear preferential attachment 181
 supercritical 87–9
 super-spreader 380
- susceptible 382
 Susceptible-Infected (SI) model 383–5
 Susceptible-Infected-Recovered (SIR)
 model 387–8
 Susceptible-Infected-Susceptible (SIS)
 model 385–7
- targeted immunization 432–3
 temporal networks 402
 terrorism 30
 testing communities 351–6
 time in networks 174
 top 1% 116
 topological overlap 332
 topological overlap matrix 331–2
 total degree 48
 trade networks 24
 Traveling Salesman 330
 tripartite network 58
 Twitter 29, 406
- ultimate impact 211
 ultra-small-world property 131–4
 undirected 45
 undirected network 52
 universality 26–7, 127
- University of Notre Dame 3
 University of Porto 11
 upper natural cutoff 104
- vaccination strategies 411
 value of a network 55
 vertex cover 258
 vertices 45
 Vespignani, Alessandro 17, 37, 389
 vulnerability due to interconnectivity
 22
- Watts and Strogatz 9, 226
 Watts, Duncan 11, 97
 Watts-Strogatz model 9, 97
 weak community 326
 Web crawler 10
 weighted networks 54
 winner-takes-all phenomenon 181, 215
 World Wide Web 3
 WWW 5, 10, 46, 93, 113, 116, 167
- Xulvi-Brunet and Sokolov algorithm
 254–5
- Zachary's Karate Club 323