

Contents

List of Contributors.....	xv
About the Editors	xix
Preface.....	xxi
Acknowledgments.....	xxv

PART I BIG DATA SCIENCE

CHAPTER 1 Big Data Analytics = Machine Learning + Cloud Computing	3
1.1 Introduction.....	3
1.2 A Historical Review of Big Data	4
1.2.1 The Origin of Big Data	4
1.2.2 Debates of Big Data Implication	5
1.3 Historical Interpretation of Big Data	7
1.3.1 Methodology for Defining Big Data.....	7
1.3.2 Different Attributes of Definitions.....	7
1.3.3 Summary of 7 Types Definitions of Big Data	10
1.3.4 Motivations Behind the Definitions.....	10
1.4 Defining Big Data From 3Vs to 3 ² Vs	11
1.4.1 Data Domain	11
1.4.2 Business Intelligent (BI) Domain	11
1.4.3 Statistics Domain	13
1.4.4 3 ² Vs Definition and Big Data Venn Diagram	13
1.5 Big Data Analytics and Machine Learning.....	14
1.5.1 Big Data Analytics	14
1.5.2 Machine Learning	15
1.6 Big Data Analytics and Cloud Computing	18
1.7 Hadoop, HDFS, MapReduce, Spark, and Flink.....	18
1.7.1 Google File System (GFS) and HDFS.....	20
1.7.2 MapReduce	24
1.7.3 The Origin of the Hadoop Project.....	25
1.7.4 Spark and Spark Stack	27
1.7.5 Flink and Other Data Process Engines	27
1.7.6 Summary of Hadoop and Its Ecosystems	32
1.8 ML + CC → BDA and Guidelines	34
1.9 Conclusion	35
References.....	35

CHAPTER 2 Real-Time Analytics	39
2.1 Introduction.....	39
2.2 Computing Abstractions for Real-Time Analytics	40
2.3 Characteristics of Real-Time Systems.....	41
2.3.1 Low Latency	42
2.3.2 High Availability.....	42
2.3.3 Horizontal Scalability	43
2.4 Real-Time Processing for Big Data — Concepts and Platforms.....	43
2.4.1 Event	43
2.4.2 Event Processing.....	44
2.4.3 Event Stream Processing and Data Stream Processing	44
2.4.4 Complex Event Processing	44
2.4.5 Event Type	45
2.4.6 Event Pattern	45
2.5 Data Stream Processing Platforms.....	45
2.5.1 Spark	46
2.5.2 Storm.....	47
2.5.3 Kafka.....	47
2.5.4 Flume	48
2.5.5 Amazon Kinesis.....	48
2.6 Data Stream Analytics Platforms.....	48
2.6.1 Query-Based EPSS.....	48
2.6.2 Rule-Oriented EPSS.....	49
2.6.3 Programmatic EPSS	50
2.7 Data Analysis and Analytic Techniques	53
2.7.1 Data Analysis in General	53
2.7.2 Data Analysis for Stream Applications	53
2.8 Finance Domain Requirements and a Case Study	54
2.8.1 Real-Time Analytics in Finance Domain	54
2.8.2 Selected Scenarios	55
2.8.3 CEP Application as a Case Study	55
2.9 Future Research Challenges	58
References.....	59
CHAPTER 3 Big Data Analytics for Social Media	63
3.1 Introduction.....	63
3.2 NLP and Its Applications.....	63
3.2.1 Language Detection	64
3.2.2 Named Entity Recognition	68
3.3 Text Mining.....	72

3.3.1 Sentiment Analysis	72
3.3.2 Trending Topics	77
3.3.3 Recommender Systems.....	81
3.4 Anomaly Detection.....	85
Acknowledgments	88
References.....	89
CHAPTER 4 Deep Learning and Its Parallelization	95
4.1 Introduction.....	95
4.1.1 Application Background.....	95
4.1.2 Performance Demands for Deep Learning	96
4.1.3 Existing Parallel Frameworks of Deep Learning.....	96
4.2 Concepts and Categories of Deep Learning	96
4.2.1 Deep Learning	96
4.2.2 Mainstream Deep Learning Models	99
4.3 Parallel Optimization for Deep Learning.....	104
4.3.1 Convolutional Architecture for Fast Feature Embedding	104
4.3.2 DistBelief	111
4.3.3 Deep Learning Based on Multi-GPUs.....	112
4.4 Discussions	115
4.4.1 Grand Challenges of Deep Learning in Big Data.....	115
4.4.2 Future Directions	116
References.....	117
CHAPTER 5 Characterization and Traversal of Large Real-World Networks.....	119
5.1 Introduction.....	119
5.2 Background.....	120
5.3 Characterization and Measurement	121
5.4 Efficient Complex Network Traversal	124
5.4.1 HPC Traversal of Large Networks.....	124
5.4.2 Algorithms for Accelerating AS-BFS on GPU	125
5.4.3 Performance Study of AS-BFS on GPU's.....	126
5.5 k-Core-Based Partitioning for Heterogeneous Graph Processing.....	128
5.5.1 Graph Partitioning for Heterogeneous Computing	129
5.5.2 k -Core-Based Complex-Network Unbalanced Bisection	129
5.6 Future Directions	133
5.7 Conclusions.....	133
Acknowledgments	134
References.....	134

PART II BIG DATA INFRASTRUCTURES AND PLATFORMS

CHAPTER 6 Database Techniques for Big Data	139
6.1 Introduction.....	139
6.2 Background.....	139
6.2.1 Navigational Data Models	139
6.2.2 Relational Data Models	140
6.3 NoSQL Movement.....	143
6.4 NoSQL Solutions for Big Data Management.....	144
6.5 NoSQL Data Models	150
6.5.1 Key-Value Stores	150
6.5.2 Column-Based Stores	151
6.5.3 Graph-Based Stores	153
6.5.4 Document-Based Stores.....	154
6.6 Future Directions	156
6.7 Conclusions.....	157
References.....	157
CHAPTER 7 Resource Management in Big Data Processing Systems	161
7.1 Introduction.....	161
7.2 Types of Resource Management.....	162
7.2.1 CPU and Memory Resource Management	162
7.2.2 Storage Resource Management	163
7.2.3 Network Resource Management.....	163
7.3 Big Data Processing Systems and Platforms	163
7.3.1 Hadoop.....	163
7.3.2 Dryad	164
7.3.3 Pregel	164
7.3.4 Storm.....	164
7.3.5 Spark	165
7.3.6 Summary	165
7.4 Single-Resource Management in the Cloud	166
7.4.1 Desired Resource Allocation Properties	166
7.4.2 Problems for Existing Fairness Policies	167
7.4.3 Long-Term Resource Allocation Policy	168
7.4.4 Experimental Evaluation.....	170
7.5 Multiresource Management in the Cloud	171
7.5.1 Resource Allocation Model	172
7.5.2 Multiresource Fair Sharing Issues	174
7.5.3 Reciprocal Resource Fairness	175
7.5.4 Experimental Evaluation.....	179

7.6	Related Work on Resource Management.....	182
7.6.1	Resource Utilization Optimization	182
7.6.2	Power and Energy Cost Saving Optimization	182
7.6.3	Monetary Cost Optimization	182
7.6.4	Fairness Optimization	183
7.7	Open Problems.....	183
7.7.1	SLA Guarantee for Applications	183
7.7.2	Various Computation Models and Systems	183
7.7.3	Exploiting Emerging Hardware	184
7.8	Summary.....	184
	References.....	184
CHAPTER 8	Local Resource Consumption Shaping: A Case for MapReduce	189
8.1	Introduction.....	189
8.2	Motivation.....	191
	8.2.1 Pitfalls of Fair Resource Sharing	192
8.3	Local Resource Shaper	194
	8.3.1 Design Philosophy	194
	8.3.2 Splitter.....	195
	8.3.3 The Interleave MapReduce Scheduler	195
8.4	Evaluation	198
	8.4.1 Experiments With Hadoop 1.x.....	198
	8.4.2 Experiments With Hadoop 2.x.....	204
8.5	Related Work	210
8.6	Conclusions.....	211
	Appendix CPU Utilization With Different Slot Configurations and LRS.....	212
	References.....	213
CHAPTER 9	System Optimization for Big Data Processing	215
9.1	Introduction.....	215
9.2	Basic Framework of the Hadoop Ecosystem	217
9.3	Parallel Computation Framework: MapReduce.....	218
	9.3.1 Improvements of MapReduce Framework	218
	9.3.2 Optimization for Task Scheduling and Load Balancing of MapReduce	219
9.4	Job Scheduling of Hadoop.....	220
	9.4.1 Built-In Scheduling Algorithms of Hadoop	220
	9.4.2 Improvement of the Hadoop Job Scheduling Algorithm.....	221
	9.4.3 Improvement of the Hadoop Job Management Framework	223
9.5	Performance Optimization of HDFS	224
	9.5.1 Small File Performance Optimization	224
	9.5.2 HDFS Security Optimization.....	226

9.6	Performance Optimization of HBase	228
9.6.1	HBase Framework, Storage, and Application Optimization	228
9.6.2	Load Balancing of HBase	229
9.6.3	Optimization of HBase Configuration	230
9.7	Performance Enhancement of Hadoop System	230
9.7.1	Efficiency Optimization of Hadoop	231
9.7.2	Availability Optimization of Hadoop	232
9.8	Conclusions and Future Directions	233
	References	233

CHAPTER 10 Packing Algorithms for Big Data Replay on Multicore..... 239

10.1	Introduction	239
10.2	Performance Bottlenecks	241
10.2.1	Hadoop/MapReduce Performance Bottlenecks	241
10.2.2	Performance Bottlenecks Under Parallel Loads	243
10.2.3	Parameter Spaces for Storage and Shared Memory	244
10.2.4	Main Storage Performance	245
10.2.5	Shared Memory Performance	248
10.3	The Big Data Replay Method	250
10.3.1	The Replay Method	250
10.3.2	Jobs as Sketches on a Timeline	251
10.3.3	Performance Bottlenecks Under Replay	252
10.4	Packing Algorithms	253
10.4.1	Shared Memory Performance Tricks	253
10.4.2	Big Data Replay at Scale	255
10.4.3	Practical Packing Models	256
10.5	Performance Analysis	256
10.5.1	Hotspot Distributions	256
10.5.2	Modeling Methodology	258
10.5.3	Processing Overhead Versus Bottlenecks	259
10.5.4	Control Grain for Drop Versus Drag Models	261
10.6	Summary and Future Directions	262
	References	264

PART III BIG DATA SECURITY AND PRIVACY

CHAPTER 11	Spatial Privacy Challenges in Social Networks	269
11.1	Introduction	269
11.2	Background	269
11.3	Spatial Aspects of Social Networks	271

11.4	Cloud-Based Big Data Infrastructure	273
11.5	Spatial Privacy Case Studies.....	275
11.6	Conclusions.....	281
	Acknowledgments	282
	References.....	282
CHAPTER 12 Security and Privacy in Big Data		285
12.1	Introduction.....	285
12.2	Secure Queries Over Encrypted Big Data	287
	12.2.1 System Model	287
	12.2.2 Threat Model and Attack Model.....	288
	12.2.3 Secure Query Scheme in Clouds	289
	12.2.4 Security Definition of Index-Based Secure Query Techniques	291
	12.2.5 Implementations of Index-Based Secure Query Techniques	291
12.3	Other Big Data Security.....	295
	12.3.1 Digital Watermarking	295
	12.3.2 Self-Adaptive Risk Access Control	296
12.4	Privacy on Correlated Big Data	296
	12.4.1 Correlated Data in Big Data	296
	12.4.2 Anonymity	298
	12.4.3 Differential Privacy	300
12.5	Future Directions	304
12.6	Conclusions.....	305
	References.....	305
CHAPTER 13 Location Inferring in Internet of Things and Big Data		309
13.1	Introduction.....	309
13.2	Device-Based Sensing Using Big Data	310
	13.2.1 Introduction.....	310
	13.2.2 Approach Overview	310
	13.2.3 Trajectories Matching	311
	13.2.4 Establishing the Mapping Between Floor Plan and RSS Readings.....	314
	13.2.5 User Localization.....	318
	13.2.6 Graph Matching Based Tracking	318
	13.2.7 Evaluation	318
13.3	Device-Free Sensing Using Big Data	319
	13.3.1 Customer Behavior Identification.....	319
	13.3.2 Human Object Estimation.....	328
13.4	Conclusion	334
	Acknowledgements.....	334
	References.....	334

PART IV BIG DATA APPLICATIONS

CHAPTER 14 A Framework for Mining Thai Public Opinions	339
14.1 Introduction.....	339
14.2 XDOM	340
14.2.1 Data Sources	340
14.2.2 DOM System Architecture	341
14.2.3 MapReduce Framework.....	342
14.2.4 Sentiment Analysis	343
14.2.5 Clustering-Based Summarization Framework	344
14.2.6 Influencer Analysis.....	349
14.2.7 AskDOM: Mobile Application.....	350
14.3 Implementation	350
14.3.1 Server.....	350
14.3.2 Core Service.....	351
14.3.3 I/O	351
14.4 Validation	352
14.4.1 Validation Parameter.....	352
14.4.2 Validation method.....	352
14.4.3 Validation results	352
14.5 Case Studies.....	353
14.5.1 Political Opinion: #prayforthailand	353
14.5.2 Bangkok Traffic Congestion Ranking	353
14.6 Summary and Conclusions	354
Acknowledgments	354
References.....	355
CHAPTER 15 A Case Study in Big Data Analytics: Exploring Twitter Sentiment Analysis and the Weather	357
15.1 Background.....	357
15.2 Big Data System Components	358
15.2.1 System Back-End Architecture.....	358
15.2.2 System Front-End Architecture	359
15.2.3 Software Stack	360
15.3 Machine-Learning Methodology	360
15.3.1 Tweets Sentiment Analysis.....	361
15.3.2 Weather and Emotion Correlation Analysis	371
15.4 System Implementation	373
15.4.1 Home Page.....	373
15.4.2 Sentiment Pages.....	374
15.4.3 Weather Pages.....	374

15.5	Key Findings.....	378
15.5.1	Time Series	378
15.5.2	Analysis with Hourly Weather Data.....	378
15.5.3	Analysis with Daily Weather Data.....	380
15.5.4	DBSCAN Cluster Algorithm.....	382
15.5.5	Straightforward Weather Impact on Emotion.....	383
15.6	Summary and Conclusions	384
	Acknowledgments	387
	References.....	387
CHAPTER 16 Dynamic Uncertainty-Based Analytics for Caching Performance Improvements in Mobile Broadband Wireless Networks.....		389
16.1	Introduction.....	389
16.1.1	Big Data Concerns	391
16.1.2	Key Focus Areas	391
16.2	Background.....	392
16.2.1	Cellular Network and VoD	392
16.2.2	Markov Processes	393
16.3	Related Work	395
16.4	VoD Architecture	396
16.5	Overview.....	398
16.6	Data Generation	399
16.7	Edge and Core Components	400
16.8	INCA Caching Algorithm.....	401
16.9	QoE Estimation.....	403
16.10	Theoretical Framework	403
16.11	Experiments and Results.....	404
16.11.1	Cache Hits With N_U , N_C , N_M and k	405
16.11.2	QoE Impact With Prefetch Bandwidth	407
16.11.3	User Satisfaction With Prefetch Bandwidth	409
16.12	Synthetic Dataset	409
16.12.1	INCA Hit Gain.....	410
16.12.2	QoE Performance.....	410
16.12.3	Satisfied Users	412
16.13	Conclusions and Future Directions.....	413
	References.....	414
CHAPTER 17 Big Data Analytics on a Smart Grid: Mining PMU Data for Event and Anomaly Detection.....		417
17.1	Introduction.....	417
17.2	Smart Grid With PMUs and PDCs	418

17.3	Improving Traditional Workflow	418
17.4	Characterizing Normal Operation.....	419
17.5	Identifying Unusual Phenomena.....	420
17.6	Identifying Known Events	423
17.7	Related Efforts	426
17.8	Conclusion and Future Directions	427
	Acknowledgments	428
	References.....	428
CHAPTER 18	eScience and Big Data Workflows in Clouds:	
	A Taxonomy and Survey	431
18.1	Introduction.....	431
18.2	Background.....	432
	18.2.1 History	432
	18.2.2 Grid-Based eScience.....	434
	18.2.3 Cloud Computing.....	435
18.3	Taxonomy and Review of eScience Services in the Cloud.....	436
	18.3.1 Infrastructure.....	437
	18.3.2 Ownership.....	437
	18.3.3 Application	438
	18.3.4 Processing Tools	439
	18.3.5 Storage	439
	18.3.6 Security	440
	18.3.7 Service Models	441
	18.3.8 Collaboration	441
18.4	Resource Provisioning for eScience Workflows in Clouds	442
	18.4.1 Motivation.....	442
	18.4.2 Our Solution.....	445
18.5	Open Problems.....	451
18.6	Summary.....	452
	References.....	452
	Index	457