
Contents

1	Introduction	1
1.1	Big Data Problem	1
1.2	A Star Is Born: The MapReduce/Hadoop Framework	4
1.3	From Big Data to Big Graphs	9
1.4	Use Cases for Big Graphs	11
1.4.1	Social Networks	11
1.4.2	Web Graph	11
1.4.3	Knowledge Bases and Linked Data	14
1.4.4	Road Networks and Location-Based Services	16
1.4.5	Chemical and Biological Networks	17
1.5	Graph Databases	17
1.6	Does Hadoop Work Well for Big Graph Processing?	19
1.7	BSP Programming Model and Google Pregel	22
1.8	Pregel Extensions	24
1.9	Giraph: BSP + Hadoop for Graph Processing	27
1.10	Book Roadmap	31
1.11	How to Use the Code Examples of This Book?	32
2	Installing and Getting Giraph Ready to Use	35
2.1	Installing Hadoop	35
2.1.1	Single-Node Local Mode Installation	36
2.1.2	Single-Node Pseudo-Distributed Installation	38
2.1.3	Multi-node Cluster Installation	43
2.2	Monitoring Hadoop	46
2.2.1	Hadoop Web User Interfaces	46
2.3	Installing Giraph	50
2.4	Installing Giraph from Source Code	51
2.5	Running an Example Giraph Job	53
2.5.1	Hadoop Local Mode	53
2.5.2	Pseudo-Distributed and Clustered Hadoop Mode	55
2.6	Monitoring Giraph Application Life Cycle	56
2.6.1	MasterObserver	57
2.6.2	WorkerObserver	57

2.7	Monitoring Giraph Jobs	57
2.7.1	Using Hadoop Commands to Monitor Giraph Jobs.	58
2.7.2	Using Hadoop UI to Monitor Giraph Jobs	62
2.8	Configuring Giraph.	62
2.8.1	Giraph-Specific Options	62
2.8.2	Job-Specific Options	63
2.8.3	Algorithm-Specific Options.	65
2.8.4	Giraph Configuration Summary.	66
2.9	Creating a Giraph IDE Project	66
2.9.1	Eclipse	68
2.9.2	Eclipse with Maven.	73
2.9.3	IntelliJ IDE	76
2.9.4	IntelliJ IDE with Maven	79
2.10	Debugging Local Zookeeper.	81
3	Getting Started with Giraph Programming	87
3.1	Giraph Graph Model.	87
3.1.1	The Edge Interface.	87
3.1.2	The Vertex Interface	88
3.1.3	The Computation Interface.	91
3.2	Vertex Similarity Algorithm	93
3.2.1	Implementation in Giraph	95
3.3	Writing a Basic Giraph Job	98
3.4	Writing the Driver Program	99
3.4.1	Using main Method.	101
3.4.2	Using Tool Interface	101
3.4.3	Using GiraphRunner Class	103
3.5	Preparing Graph Data for Giraph Input	105
3.5.1	Hadoop Distributed File System	105
3.5.2	Hadoop Input Formats.	105
3.5.3	Giraph Input Formats	106
3.5.4	Giraph Vertex Input Formats.	107
3.5.5	Edge Input Formats.	113
3.6	Preparing Graph Data for Giraph Output	113
3.6.1	Vertex Output Formats	113
3.6.2	Edge Output Formats	116
4	Popular Graph Algorithms on Giraph	119
4.1	PageRank	119
4.1.1	Example	120
4.1.2	Implementation Details	122
4.2	Connected Components	123
4.2.1	Example	123
4.2.2	Implementation Details	124

4.3	Shortest Path	127
4.3.1	Example	127
4.3.2	Implementation Details	129
4.4	Triangle Closing	131
4.4.1	Example	131
4.4.2	Implementation Details	133
4.5	Maximal Bipartite Graph Matching	135
5	Advanced Giraph Programming	141
5.1	Algorithm Optimization	141
5.1.1	MasterCompute	141
5.1.2	Data Sharing Across Nodes	143
5.1.3	Combiners	148
5.1.4	Coarse-Grained Processing	149
5.2	Dealing with More Complex Graph Algorithms	150
5.2.1	Graph Mutations	150
5.2.2	Undirected Graphs	151
5.2.3	Synchronizing the States of Neighboring Vertices	154
5.2.4	Implementing Graph Coloring	156
5.3	Performance Optimizations	162
5.3.1	Multithreading	162
5.3.2	Message Exchange Tuning	163
5.3.3	Controlling the OutEdges Class	163
5.3.4	Out-of-Core Processing	164
5.4	Giraph Custom Partitioner	166
5.5	Advanced Giraph I/O	166
5.5.1	Writing a Custom Input Format	167
5.5.2	Writing a Custom Output Format	168
5.6	Analyzing Giraph Errors	169
5.6.1	CountersExceededException	170
5.6.2	ClassNotFoundException	170
5.6.3	FileAlreadyExistsException	170
5.6.4	OutOfMemoryError	171
5.7	Failure Recovery	171
5.7.1	Checkpointing	171
5.7.2	Retrying and Recovering Failed Jobs	172
6	Related Large-Scale Graph Processing Systems	175
6.1	GraphX	175
6.1.1	Spark and RDD	175
6.1.2	GraphX RGD	179
6.1.3	Examples	183
6.2	GraphLab	189
6.2.1	Programming Model	189
6.2.2	Consistency Model	194
	References	195



<http://www.springer.com/978-3-319-47430-4>

Large-Scale Graph Processing Using Apache Giraph

Sakr, S.; Orakzai, F.M.; Abdelaziz, I.; Khayyat, Z.

2016, XXV, 197 p. 102 illus., 87 illus. in color.,

Hardcover

ISBN: 978-3-319-47430-4