

# Contents

<b>1</b>	<b>Introduction</b> . . . . .	1
1.1	What Is This Book About? . . . . .	1
1.2	Offering Technological Response to World Challenges . . . . .	1
1.3	Background and History . . . . .	2
1.3.1	Creating Distributed Networks . . . . .	2
1.3.2	Using Program Mobility . . . . .	2
1.3.3	Active Graphs and Networks . . . . .	3
1.3.4	Mobile Programs in Active Networks . . . . .	3
1.3.5	International Support . . . . .	4
1.4	The Book Organization . . . . .	5
	References . . . . .	8
<b>2</b>	<b>Some Theoretical Background</b> . . . . .	11
2.1	Introduction . . . . .	11
2.2	General Systems Theory . . . . .	11
2.3	System Dynamics . . . . .	13
2.4	Gestalt Psychology . . . . .	15
2.5	Memetics Versus Genetics . . . . .	20
2.6	Brain Waves and Consciousness . . . . .	21
2.7	Interoperability Organizations and Their Weakness . . . . .	23
2.8	Over-Operability Versus Interoperability in System Organization . . . . .	25
2.9	Conclusion . . . . .	28
	References . . . . .	28
<b>3</b>	<b>Spatial Grasp Model</b> . . . . .	31
3.1	Introduction . . . . .	31
3.2	Spatial Grasp Model Key Issues . . . . .	32
3.2.1	General Idea . . . . .	32
3.2.2	Parallel Wavelike World Coverage . . . . .	32

3.2.3	Navigation Pattern's Modification, Reduction, and Replication . . . . .	33
3.2.4	Spatial Grasp with Echo Processing . . . . .	33
3.2.5	Multisource Matching . . . . .	35
3.2.6	Combining Biological, Sociological, and Psychological Ideas . . . . .	36
3.3	General Organization of Spatial Grasp Language, SGL . . . . .	36
3.3.1	SGL Orientation and Peculiarities . . . . .	36
3.3.2	SGL Recursive Structure . . . . .	37
3.3.3	Constants . . . . .	37
3.3.4	Variables . . . . .	38
3.3.5	Rules . . . . .	38
3.4	More SGL Details . . . . .	38
3.4.1	SGL Worlds . . . . .	39
3.4.2	How SGL Scenarios Evolve . . . . .	39
3.4.3	Sense and Nature of SGL Rules . . . . .	40
3.4.4	The Use of SGL Variables . . . . .	41
3.4.5	SGL Control States and Their Hierarchical Merge . . . . .	42
3.5	Elementary Examples in SGL . . . . .	43
3.6	General Issues of SGL Networked Interpretation . . . . .	52
3.7	Conclusion . . . . .	53
	References . . . . .	54
<b>4</b>	<b>SGL Detailed Specification . . . . .</b>	<b>57</b>
4.1	Introduction . . . . .	57
4.2	Full SGL Syntax and Main Constructs . . . . .	57
4.3	SGL Constants . . . . .	60
4.3.1	Information . . . . .	60
4.3.2	Physical Matter . . . . .	60
4.3.3	Custom Constants . . . . .	61
4.3.4	Special Constants . . . . .	61
4.3.5	Compound Constants, Grasps . . . . .	62
4.4	SGL Variables . . . . .	62
4.4.1	Global, Heritable, Frontal, and Nodal Variables . . . . .	62
4.4.2	Environmental Variables . . . . .	62
4.5	SGL Rules . . . . .	66
4.5.1	Movement . . . . .	66
4.5.2	Creation . . . . .	67
4.5.3	Echoing . . . . .	68
4.5.4	Verification . . . . .	70
4.5.5	Assignment . . . . .	70
4.5.6	Advancement . . . . .	71
4.5.7	Branching . . . . .	72
4.5.8	Transference . . . . .	75

4.5.9	Timing . . . . .	76
4.5.10	Granting . . . . .	77
4.5.11	Type . . . . .	78
4.5.12	Usage . . . . .	78
4.5.13	Application . . . . .	79
4.5.14	Grasp . . . . .	79
4.6	Conclusion . . . . .	79
	References. . . . .	80
<b>5</b>	<b>Main Spatial Mechanisms in SGL . . . . .</b>	<b>81</b>
5.1	Introduction . . . . .	81
5.2	Progress Points or Props . . . . .	81
5.3	Single Grasp Representation . . . . .	82
5.4	Depth Mode Space Navigation . . . . .	84
5.4.1	Advancement. . . . .	84
5.4.2	Sliding . . . . .	87
5.4.3	Repetition . . . . .	88
5.5	Breadth Mode Navigation . . . . .	91
5.5.1	General Branching . . . . .	92
5.5.2	IF-THEN-ELSE Branching . . . . .	94
5.5.3	OR Branching . . . . .	94
5.5.4	AND Branching . . . . .	96
5.5.5	Repetitive Branching . . . . .	97
5.6	Breadth-Depth Combined Navigation Mode . . . . .	100
5.6.1	General Breadth-Depth Mode . . . . .	100
5.6.2	Asynchronous-Parallel Mode . . . . .	101
5.6.3	Synchronous-Parallel Mode . . . . .	102
5.7	Direct Operations on Remote Values . . . . .	103
5.8	Conclusion . . . . .	104
	References. . . . .	105
<b>6</b>	<b>SGL Networked Interpreter . . . . .</b>	<b>107</b>
6.1	Introduction . . . . .	107
6.2	The Interpreter General Organization . . . . .	108
6.3	Data Structures of the Interpreter . . . . .	108
6.3.1	Grasps Queue . . . . .	109
6.3.2	Suspended Grasps . . . . .	109
6.3.3	Track Forest . . . . .	109
6.3.4	Activated Rules . . . . .	110
6.3.5	Knowledge Network . . . . .	110
6.3.6	Grasps Identities . . . . .	110
6.3.7	Heritable Variables . . . . .	111
6.3.8	Fontal Variables. . . . .	111

6.3.9	Nodal Variables . . . . .	111
6.3.10	Environmental Variables . . . . .	112
6.3.11	Global Variables . . . . .	112
6.3.12	Incoming Queue . . . . .	112
6.3.13	Outgoing Queue . . . . .	113
6.4	Functional Processors . . . . .	113
6.4.1	Communication Processor . . . . .	113
6.4.2	Parser. . . . .	113
6.4.3	Operation Processors . . . . .	114
6.4.4	Navigation Processor. . . . .	114
6.4.5	Control Processor . . . . .	114
6.4.6	World Access Unit . . . . .	115
6.5	Track-Based Automatic Command and Control . . . . .	115
6.5.1	Track-Based Management Components . . . . .	115
6.5.2	Forward Grasping . . . . .	117
6.5.3	Distribution of Track Structure . . . . .	118
6.5.4	Echoing Via Tracks. . . . .	118
6.5.5	Failed and Blocked Track Branches . . . . .	120
6.5.6	Further World Grasping. . . . .	120
6.5.7	More Advanced Track Infrastructure . . . . .	123
6.6	Examples of Involvement of Interpreter Components . . . . .	124
6.6.1	Transferring Control Messages . . . . .	124
6.6.2	Engagement in Data Processing. . . . .	125
6.6.3	Networked Knowledge Processing. . . . .	127
6.6.4	Movement in Physical Space. . . . .	128
6.7	Integration with Other Systems. . . . .	129
6.8	Conclusions . . . . .	131
	References. . . . .	131
<b>7</b>	<b>Creation, Activation, and Management of a Distributed World. . .</b>	<b>133</b>
7.1	Introduction . . . . .	133
7.2	Distributed World Creation. . . . .	134
7.2.1	Elementary Examples . . . . .	134
7.2.2	Creating General Networks . . . . .	136
7.3	Network Distribution . . . . .	142
7.4	World's Invasion with Mobile Objects . . . . .	144
7.5	Collecting and Exhibiting the History of Navigation . . . . .	145
7.6	Adding Nodal Activity . . . . .	146
7.7	Global Supervision and Inspection . . . . .	148
7.8	Runtime Restructuring of the Active Distributed World . . . . .	150

7.9	Virtual-Physical World Creation and Management . . . . .	152
7.9.1	Converting Virtual to Physical. . . . .	152
7.9.2	Keeping Size and Shape in Movement . . . . .	153
7.9.3	Creating Physical Structures from the Start . . . . .	155
7.10	Conclusion . . . . .	156
	References. . . . .	156
<b>8</b>	<b>Parallel and Distributed Network Operations . . . . .</b>	<b>159</b>
8.1	Introduction . . . . .	159
8.2	Finding Simple Paths Between Nodes . . . . .	160
8.2.1	All Simple Paths . . . . .	160
8.2.2	Limited Length Simple Paths. . . . .	161
8.2.3	Using Constraints on Links . . . . .	161
8.2.4	Constraints on Both Links and Nodes . . . . .	162
8.2.5	Taking into Account Orientation of Links . . . . .	162
8.2.6	Issuing the Paths in the Final Node. . . . .	163
8.3	Creating Shortest Path Tree . . . . .	163
8.4	Finding Shortest Path Between Nodes . . . . .	164
8.4.1	Single Source Solution . . . . .	164
8.4.2	Two-Source Solution . . . . .	165
8.5	Moving Physical Matter via the Path Found. . . . .	166
8.5.1	Matter Moving Along the Path . . . . .	167
8.5.2	Matter Moving Opposite the Path . . . . .	167
8.6	Finding Weak and Strong Components in Networks . . . . .	168
8.6.1	Finding Weakest Points . . . . .	168
8.6.2	Finding Strongest Parts . . . . .	170
8.7	Finding Arbitrary Structures in Arbitrary Networks . . . . .	172
8.7.1	Exemplary Network and Search Template. . . . .	172
8.7.2	Template Representation Based on a Path Through All Nodes . . . . .	172
8.7.3	Template Representation Based on a Path Through All Links. . . . .	174
8.7.4	Networks with Named Nodes and Links . . . . .	175
8.7.5	Working with Networks Having Multiple Links Between Nodes . . . . .	177
8.8	Examples of Finding Particular Structures . . . . .	177
8.8.1	Example 1: Triangle . . . . .	178
8.8.2	Example 2: Two Triangles Sharing a Side. . . . .	179
8.8.3	Example 3: Unlimited Expanding Structure. . . . .	180
8.9	Conclusion . . . . .	181
	References. . . . .	181

<b>9</b>	<b>Solving Societal Problems</b>	183
9.1	Introduction	183
9.2	Social Problems and Social Networks	184
9.2.1	Social Problems Examples	184
9.2.2	Human Terrain Concept and Its Relation to Social Problems	184
9.2.3	Social Networks and Their Representation	186
9.3	Exemplary Social Network Operations	187
9.3.1	Distributed Counting of the Number of Nodes and Links	187
9.3.2	Finding Paths Between Nodes	188
9.3.3	Shortest Path Tree and Solutions Based on It	191
9.3.4	Spatial Centres of Organizations	195
9.4	Active and Assisted Living	198
9.5	Emergency Management	200
9.5.1	Investigating and Relieving Disaster Consequences	200
9.5.2	Collective Evacuation from a Disaster Zone	201
9.6	Other Societal Tasks Currently Investigated Under SGT	202
9.7	Conclusion	203
	References	203
<b>10</b>	<b>Automated Command and Control</b>	205
10.1	Introduction	205
10.2	Purely Semantic Scenario with Automatic Control	206
10.2.1	Exemplary Task	206
10.2.2	Three-Doer Task Solution	207
10.2.3	Task Solution with Other Numbers of Doers	212
10.3	Dynamic Creation of Distributed Command Infrastructures	213
10.3.1	Hierarchical Operational Infrastructure	214
10.3.2	Peripheral, Ring Infrastructure	218
10.4	Withstanding Cruise Missiles	220
10.4.1	Existing Solutions	220
10.4.2	Installing SGL Interpreters in Distributed Sensors	221
10.4.3	Distributed Missile Tracking Scenario in SGL	222
10.4.4	Withstanding Multiple Attacks	224
10.5	Networked Night Vision Scenarios	226
10.5.1	Multiple Spatial Vision of a Particular Object	226
10.5.2	Multiple Spatial Vision of the Whole Theatre	228
10.6	Europe-Related Missile Defense Scenario	229
10.6.1	Missile Defense Main Stages	229
10.6.2	Missile Defense Management in SGL	232

10.7	High-Level Battle Management in SGL . . . . .	233
10.7.1	Traditional Battle Management in BML . . . . .	233
10.7.2	Same Management Scenario in SGL . . . . .	235
10.8	Distributed Avionics . . . . .	237
10.9	Conclusion . . . . .	238
	References. . . . .	239
<b>11</b>	<b>Collective Robotics . . . . .</b>	<b>241</b>
11.1	Introduction . . . . .	241
11.2	Some Modern Robotic Examples . . . . .	242
11.2.1	Ground Robotics . . . . .	242
11.2.2	Aerial Robotics . . . . .	242
11.2.3	Maritime Robotics . . . . .	243
11.2.4	Collectively Behaving Robots . . . . .	244
11.2.5	General Demands to Advanced Robotic Systems . . . . .	245
11.3	Integration of Loose Swarming with Hierarchical Command and Control. . . . .	246
11.4	Multi-robot Hospital Service Example . . . . .	250
11.5	Exploration and Mapping of Unknown Distributed Space . . . . .	252
11.5.1	Different Mapping Scenarios . . . . .	253
11.5.2	Finding Optimal Route by the Created Free Space Grid. . . . .	256
11.6	Battling Forest Fires with Robotic Swarms. . . . .	257
11.7	Coastal Waters Cooperative Patrol . . . . .	259
11.8	Cooperative Finding of Oil Spill Center. . . . .	261
11.9	Maritime Massive Robotic Attack. . . . .	263
11.10	Swarm Against Swarm Aerial Scenario . . . . .	265
11.11	Cooperative Robotic Forestry and Agriculture . . . . .	266
11.12	Conclusion . . . . .	272
	References. . . . .	272
<b>12</b>	<b>Conclusions . . . . .</b>	<b>275</b>
12.1	General Advantages of the Technology Developed. . . . .	275
12.2	Contribution to the System Theory and Practice. . . . .	275
12.3	Some Particular Application Areas . . . . .	279
12.4	Implementation Issues and Future Plans . . . . .	282
	References. . . . .	282

Managing Distributed Dynamic Systems with Spatial  
Grasp Technology

Sapaty, P.S.

2017, XVII, 284 p. 215 illus., 167 illus. in color.,

Hardcover

ISBN: 978-3-319-50459-9