
CONTENTS

1	What Is Context-Aware Behavior?	1
1.1	Current Computing Trends: From the Virtual to the Physical	2
1.2	Context, Context Awareness, and Situations.....	4
1.3	When Systems Become Context Aware	7
1.4	An Overview of This Book	8
	References.....	10
2	The Structure and Elements of Context-Aware Pervasive Systems	13
2.1	Analogies.....	13
2.2	The Elements of a Context-Aware Pervasive System	15
2.2.1	Sensing.....	15
2.2.2	Thinking.....	20
2.2.3	Acting.....	24
2.3	An Abstract Architecture	24
2.4	Infrastructures, Middleware, and Toolkits	26
2.5	Issues of Security, Privacy, and Efficiency.....	27
2.6	Summary.....	27
	References.....	28
3	Context-Aware Mobile Services	31
3.1	The Rise of Mobile Services	31
3.2	Context for Mobile Device Users.....	33
3.3	Location-Based Services	33
3.4	Ambient Services	34
3.4.1	PointRock Example.....	37
3.4.2	Future E-Marketplaces	38
3.4.3	Office Building Example	42
3.4.4	A Software Architecture for Ambient Services	44
3.5	From Ambient Services to Place-Based E-Communities	49
3.5.1	Interaction between User and Community Server.....	50

3.5.2	Interaction between User and Multiple Communities: Impact of User Movement.....	51
3.6	Enhancing Context-Aware Mobile Services with Mobile Code and Policy: The MHS Example	52
3.6.1	MHS Architecture	53
3.6.1.1	Policy Conflict Resolution	54
3.6.2	Context-Based Policy Control of Media Player Service	55
3.6.3	Partial Control between User and System	60
3.6.4	MHS Summary	61
3.7	Enhancing Context-Aware Mobile Services with Multiagent Technology: The Example of Proximity-Based Reverse Auctions.....	61
3.7.1	Proximity-Based Reverse Auctions	61
3.7.2	A System for Proximity-Based Reverse Auctions	63
3.7.2.1	Architectural Overview	63
3.7.2.2	From the User's Viewpoint	65
3.7.2.3	Interaction Protocols.....	67
3.7.2.4	Observing Auctions via Auction Events	68
3.8	Summary and Further Developments	70
	Acknowledgment	71
	References.....	71
4	Context-Aware Artifacts	75
4.1	Aware Objects.....	75
4.2	Architectural Design Space for a Context-Aware Artifact	82
4.3	Context-Aware Mobile Phones: An Illustration.....	84
4.3.1	Overview of a Framework for Context-Aware Mobile Phone with User Preferences: The CAMP-UP System	84
4.3.2	CAMP-UP System Interaction	85
4.3.2.1	On the Space Side.....	87
4.3.2.2	On the Client Side	88
4.3.3	Prototype and Discussions	90
4.3.4	Scenarios	93
4.4	Summary.....	99
	References.....	100
5	Context-Aware Mobile Software Agents for Interaction with Web Services in Mobile Environments.....	105
5.1	Agents: Mobile and Intelligent	105
5.2	Scenarios	106
5.3	A Brief Review of Agent Platforms for Ubiquitous Computing.....	108
5.4	CALMA Architecture	109
5.4.1	CALMA Agent Model	111
5.4.2	Server Component	115
5.4.3	Mobile Device Component	116
5.5	Prototype Implementation and Evaluation.....	116
5.5.1	Illustrative Scenarios	117
5.5.1.1	Booking Movie Tickets	117

5.5.1.2	Finding an IDD Calling Card.....	117
5.5.2	Enabling Lightweight Behavior.....	120
5.5.3	Enabling Context Awareness.....	122
5.5.4	Performance Evaluation.....	122
5.6	Summary.....	124
	Acknowledgments.....	125
	References.....	125
6	Context-Aware Addressing and Communication for People, Things, and Software Agents.....	127
6.1	Context-Aware Communication for People.....	128
6.1.1	Application Types.....	128
6.1.2	Call Services.....	131
6.1.3	More Applications.....	132
6.1.4	Summary.....	133
6.2	Context-Aware Addressing and Commanding for Objects.....	133
6.2.1	Application Types.....	133
6.2.2	A View from Situation Semantics.....	134
6.2.3	Summary.....	137
6.3	Context-Aware Communication for Software Agents.....	138
6.3.1	Addressing Agents via Context.....	138
6.3.2	Applications.....	139
6.4	Summary and Conclusion.....	140
	References.....	141
7	Context-Aware Sensor Networks.....	143
7.1	Context-Aware Sensors: The Concept.....	143
7.2	A Framework for Context-Aware Sensors.....	145
7.2.1	Sensor Roles.....	145
7.2.2	Categorizing Energy Consumption.....	146
7.2.2.1	Input Alphabet.....	146
7.2.2.2	Output Alphabet.....	147
7.2.2.3	Energy States.....	148
7.2.3	Architecture.....	148
7.3	Implementation and Application Scenario.....	152
7.3.1	Experimental Investigations.....	153
7.4	Summary.....	156
	Acknowledgment.....	156
	References.....	157
8	Context-Aware Security.....	159
8.1	Traditional Security Issues and Models.....	161
8.2	Context-Aware Security Systems.....	162
8.2.1	Examples.....	162
8.2.2	Context-Aware Policies.....	164
8.2.2.1	Contextual Graphs.....	165
8.2.2.2	Logic.....	166
8.2.2.3	Roles.....	167

8.3	From Context-Aware Security to Context-Aware Safety	169
8.4	Summary	170
	References	170
9	Context Awareness and Mirror-World Models	173
9.1	Gelernter's Mirror Worlds	173
9.2	Nexus	175
9.3	Virtual Worlds, Virtual Environments	176
9.3.1	Aura, Focus, and Nimbus: Virtual Objects and Real-World Objects	177
9.4	Digital Cities	181
9.5	Aware Spaces: Smart Environments and Smart Spaces	183
9.6	Mirror Worlds: Context and Ontologies	185
9.7	Summary	186
	References	186
10	Constructing Context-Aware Pervasive Systems: Declarative Approaches and Design Patterns	189
10.1	Representing Situations	190
10.1.1	The Situation Program	191
10.1.2	Modularity	193
10.2	Five Other Ways to Represent a Meeting	194
10.2.1	Observations	197
10.3	Metaprogramming with Situation Programs: Examples	198
10.4	Another Declarative Approach	199
10.5	Toward Design Patterns for Context-Aware Applications: Situation Patterns	201
10.6	Summary	205
	Acknowledgment	205
	References	205
11	A Future with Aware Systems	207
11.1	The Emerging Future: Taking Awareness for Granted	207
11.2	Scalability and Usability	208
11.3	Final Words	209
	Index	211