

# Developing Multi-Agent Systems with JADE

**Fabio Bellifemine**, *Telecom Italia, Italy*

**Giovanni Caire**, *Telecom Italia, Italy*

**Dominic Greenwood**, *Whitestein Technologies AG, Switzerland*

**The JADE Platform**

- 1.1 The JADE architecture
- 1.2 JADE components
- 1.3 JADE packages
- 1.4 Computing behavioural models
- 1.5 JADE packages
- 1.6 Mobile support service
- 1.7 Admin and debugging tools

**2 Programming with JADE - Basic Features**

- 2.1 Creating agents
- 2.2 Agent life
- 2.3 Agent communication
- 2.4 Agent discovery and the yellow pages
- 2.5 Agent mobility

**3 Programming with JADE - Advanced Features**

- 3.1 Object-oriented and control languages
- 3.2 Computing behaviours in multi-agent systems
- 3.3 Theoretical foundations
- 3.4 Interaction protocols
- 3.5 Interacting with the JADE



John Wiley & Sons, Ltd

# Contents

<b>The Authors</b>	<b>ix</b>
<b>List of Contributors</b>	<b>xi</b>
<b>Preface</b>	<b>xiii</b>
<b>1 Introduction</b>	<b>1</b>
<b>2 Agent Technology Overview</b>	<b>3</b>
2.1 About agents	3
2.2 The Foundation for Intelligent, Physical Agents (FIPA)	10
<b>3 The JADE Platform</b>	<b>29</b>
3.1 Brief history	29
3.2 JADE and the agents paradigm	30
3.3 JADE architecture	32
3.4 Compiling the software and launching the platform	34
3.5 JADE packages	37
3.6 Message transport service	39
3.7 Admin and debugging tools	42
<b>4 Programming with JADE – Basic Features</b>	<b>51</b>
4.1 Creating agents	51
4.2 Agent tasks	57
4.3 Agent communication	65
4.4 Agent discovery: the yellow pages service	72
4.5 Agents with a GUI	75
<b>5 Programming with JADE – Advanced Features</b>	<b>77</b>
5.1 Ontologies and content languages	77
5.2 Composing behaviours to create complex tasks	91
5.3 Threaded behaviours	99
5.4 Interaction protocols	100
5.5 Interacting with the AMS	107
5.6 Starting JADE from an external Java application	111
<b>6 Agent Mobility</b>	<b>115</b>
6.1 Agent mobility	115
6.2 Intra-platform mobility	117
6.3 Inter-platform mobility service	119
6.4 Usage of the JADE mobility services	121

<b>7 JADE Internal Architecture</b>	<b>131</b>
7.1 Distributed coordinated filters	131
7.2 Creating a JADE kernel service	136
<b>8 Running JADE Agents on Mobile Devices</b>	<b>145</b>
8.1 Main limitations of the mobile environment	145
8.2 The LEAP add-on	146
8.3 The split container execution mode	150
8.4 Developing MIDP agents	154
8.5 LEAP add-on advanced	161
<b>9 Deploying a Fault-Tolerant JADE Platform</b>	<b>173</b>
9.1 The main replication service	173
9.2 Attaching the DF to a relational DB	176
<b>10 The JADE Web Services Integration Gateway</b>	<b>181</b>
10.1 Web service technology	181
10.2 The utility of agent and Web service integration	182
10.3 The WSIG architecture	182
10.4 Installation requirements	184
10.5 WSIG installation procedure	185
10.6 WSIG operation	186
10.7 Example 1: Web service client invokes an agent service	193
10.8 Example 2: Agent service invokes a Web service	203
<b>11 Agent-Society Configuration Manager and Launcher</b>	<b>207</b>
11.1 Basic terms and concepts	207
11.2 Book-trading example	209
11.3 Distributed deployment	215
11.4 The XML meta-model	218
11.5 Inside the ASCML	220
11.6 Distributed monitoring, logging and debugging	222
11.7 Outlook	223
<b>12 JADE Semantics Framework</b>	<b>225</b>
12.1 FIPA-SL language	226
12.2 Interpretation engine	230
12.3 Basic semantic agent	231
12.4 Specializing the interpretation activity	234
12.5 Customizing belief handling	237
12.6 Handling Actions	240
12.7 Synthesizing standard and advanced use of the JSA	245
12.8 Conclusions	245
<b>13 A Selection of Other Relevant Tools</b>	<b>247</b>
13.1 The Bean Generator	247
13.2 JADEMX	250
13.3 The Java Sniffer	251
13.4 JADEx – engineering goal-oriented agents	254

<b>APPENDIX A</b>	<b>Command Line Options</b>	<b>259</b>
A.1	Syntax	259
A.2	Options to launch containers and main containers	260
A.3	General Options	261
A.4	Options of the JADE kernel-level services	262
A.5	Options related to MTPs	265
A.6	Options to configure the yellow page DF service	267
A.7	Options specific to the JADE-LEAP platform	268
A.8	Extending the command line with user-defined options	269
<b>APPENDIX B</b>	<b>List of Symbols and Acronyms</b>	<b>271</b>
<b>Bibliography</b>		<b>275</b>
References		275
FIPA Specifications		278
<b>Index</b>		<b>281</b>