

---

# Contents

<b>List of Figures</b> .....	xiii
<b>List of Tables</b> .....	xvii
<b>1 Introduction</b> .....	1
1.1 Industrial Automation .....	2
1.2 Automation Systems in Electricity Transmission .....	4
1.3 Network-based Power System Automation .....	5
1.4 e-Automation .....	8
1.5 Book Outline .....	9
<b>2 Agents, Multi-agent Systems and Mobile Code</b> .....	13
2.1 Overview of Agent Technology .....	13
2.2 Intelligent/Autonomous Agents .....	13
2.2.1 Definitions .....	13
2.2.2 Intelligent Agents in Information Processing and Problem Solving .....	14
2.3 Agent Architectures .....	16
2.3.1 Deliberative Architectures .....	16
2.3.2 Reactive Architectures .....	19
2.3.3 Learning-based Architectures .....	20
2.3.4 Layered Architectures .....	20
2.4 Standards for Agent Development .....	20
2.4.1 Foundation for Intelligent Physical Agents Standards ..	20
2.4.2 Mobile Agent Standards .....	25
2.5 Mobile Agent Technology .....	27
2.6 Multi-agent System .....	27
2.6.1 Architectures .....	27
2.6.2 Multi-agent Programming .....	28
2.6.3 Middle Agents: Brokers and Facilitators .....	31

2.7	Agent Application Architectures .....	32
<b>3</b>	<b>An Agent-based Architecture for Power System Automation</b>	<b>35</b>
3.1	Agents in Power Systems .....	36
3.1.1	Control .....	36
3.1.2	Negotiation and Pricing .....	37
3.1.3	Information Management .....	37
3.1.4	Condition Monitoring .....	37
3.2	Tasks Performed .....	38
3.3	A Multi-agent System for Power System Automation .....	41
3.3.1	Agent Platform .....	42
3.3.2	Data Acquisition and Control System .....	44
3.3.3	Information Management System and User Interface ...	48
3.3.4	Combined Multi-agent Architecture .....	50
3.4	Agents, Tasks and Interaction Protocols .....	52
3.5	Data and Knowledge .....	60
3.5.1	Available Data and Knowledge .....	60
3.5.2	Knowledge Representation .....	62
3.5.3	Ontologies .....	66
3.6	Agent Platform Implementation .....	67
3.6.1	Standard FIPA Platform .....	68
3.6.2	Jini <sup>TM</sup> -based Platform .....	69
3.6.3	UDP-based Platform .....	71
3.6.4	Combined FIPA and UDP-based Platform .....	71
3.7	Summary .....	72
<b>4</b>	<b>Static Components of Architecture</b> .....	<b>75</b>
4.1	Database Agents .....	76
4.1.1	Description .....	76
4.1.2	Agent Specification .....	78
4.1.3	Agent Implementation .....	78
4.2	Document Agents .....	80
4.2.1	Description .....	80
4.2.2	Agent Specification .....	81
4.2.3	Document Agent Issues .....	82
4.3	Ontology Agents .....	83
4.4	Device Agents and Node Agents .....	83
4.4.1	Description .....	83
4.4.2	Agent Specification .....	84
4.5	Plant Agents .....	85
4.5.1	Description .....	85
4.5.2	Agent Specifications .....	86
4.5.3	Data Acquisition System/Plant Mappings .....	87
4.6	User Interface Agents .....	91
4.6.1	Description .....	91

4.6.2	Agent Specification .....	91
4.7	Summary .....	92
<b>5</b>	<b>Applications of Mobile Agents .....</b>	<b>93</b>
5.1	Mobile Agent Performance .....	93
5.2	Mobile Agent for Data Analysis .....	95
5.2.1	Agent Algorithms and Implementation .....	97
5.2.2	Benchmarks .....	100
5.2.3	Discussion .....	105
5.2.4	Related Work .....	106
5.2.5	Conclusions .....	107
5.3	Mobile Agent for Remote Control of Power Systems .....	108
5.3.1	Agent Algorithms and Implementation .....	110
5.3.2	Experiment .....	112
5.3.3	Conclusions and Related Work .....	123
5.4	Summary .....	124
<b>6</b>	<b>Multi-agent-based Substation Information Management System .....</b>	<b>127</b>
6.1	Introduction .....	127
6.2	System Architecture and Agents .....	128
6.2.1	Information Management System Agents .....	129
6.2.2	Personal Assistant Agents in Substation Information Systems .....	132
6.3	System Ontology .....	133
6.4	Examples of Usage .....	135
6.4.1	Querying IMU for a Data Set .....	136
6.4.2	Mobile Agent-based Analysis of Data .....	141
6.4.3	Searching for Documents .....	142
6.4.4	Performing an Action Using Data Acquisition Agents ..	145
6.4.5	Reading a Plant Property Using Data Acquisition Agents .....	146
6.4.6	Human–Machine Interaction Using Personal Assistant Agents .....	148
6.5	Implementation Issues .....	153
6.6	Summary .....	154
<b>7</b>	<b>Evaluation and Analysis .....</b>	<b>157</b>
7.1	Functionality .....	158
7.1.1	National Grid Transco Requirements for Substation Control Systems .....	158
7.1.2	Haacke “Opportunity Matrix” .....	158
7.1.3	Summary of Functionality Results .....	160
7.2	Performance .....	160
7.2.1	Data Acquisition Performance .....	160

7.2.2	Responding to User Queries .....	163
7.2.3	Data Display .....	164
7.3	Modifiability .....	165
7.3.1	Modifying the Substation.....	165
7.3.2	Modifying the Data Sources .....	166
7.3.3	Modifying the User Interface.....	167
7.3.4	Summary.....	168
7.4	Security, Reliability and Availability .....	168
7.5	Integration into Existing Substations.....	169
7.6	Possible Applicability to Other Industries.....	170
7.7	Discussion .....	171
7.7.1	Advantages .....	171
7.7.2	Disadvantages .....	172
7.8	Summary.....	173
<b>References .....</b>		<b>175</b>
<b>Index .....</b>		<b>185</b>

IP Network-based Multi-agent Systems for Industrial  
Automation

Information Management, Condition Monitoring and  
Control of Power Systems

Buse, D.P.; Wu, Q.H.

2007, XVII, 187 p., Hardcover

ISBN: 978-1-84628-646-9