## Contents

### Part I Case Studies in Control of Distributed Systems

1. **C4C Case Studies** .............................................................. 3  
   Jan H. van Schuppen

2. **A Model Predictive Control Approach to AUVs Motion Coordination** .................................................... 9  
   Fernando Lobo Pereira, J. Borges de Sousa, R. Gomes and P. Calado

3. **Dynamic Optimization Techniques for the Motion Coordination of Autonomous Vehicles** .............................. 19  
   Jorge Estrela da Silva, João Borges de Sousa  
   and Fernando Lobo Pereira

4. **Coordination Challenges in Networked Vehicle Systems: Are We Missing Something?** ................................. 27  
   J. Borges de Sousa and Fernando Lobo Pereira

5. **Leader–Follower Coordination Control for Urban Traffic** ................................. 35  
   René Boel and Nicolae Marinică

6. **Prediction of Traffic Flow in a Road Network** ................................. 45  
   Yubin Wang, Jan H. van Schuppen and Jos L.M. Vrancken

7. **Zone-Control-Based Traffic Control of Automated Guided Vehicles** .............................................................. 53  
   Qin Li, Jan Tijmen Udding and Alexander Pogromsky

8. **Coordination Control of Complex Machines** ................................. 61  
   Jos C.M. Baeten, Bert van Beek, Jasen Markovski  
   and Lou J.A.M. Somers
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Coordinated Model-Predictive Control for Avoiding Voltage Collapse in an Electric Power Transmission Net</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>René Boel, Mohammad Moradzadeh and Lieven Vandevelde</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Part II  Architectures of Distributed Systems and Their Control</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>System Architectures of Distributed and of Multilevel Systems</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Jan H. van Schuppen</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Control Architectures</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Jan H. van Schuppen</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Part III  Coordination Control</strong></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>What is Coordination Control?</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Jan H. van Schuppen</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Introduction to Coordinated Linear Systems</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Pia L. Kempker</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Coordinated Linear Systems</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>André C.M. Ran and Jan H. van Schuppen</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>LQ Optimal Control for Coordinated Linear Systems</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Pia L. Kempker</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Supervisory Control of Discrete-Event Systems</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>Jan Komenda and Tomáš Masopust</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Coordination Control of Distributed Discrete-Event Systems</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Jan Komenda and Tomáš Masopust</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Part IV  Distributed Control</strong></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>What Is Team Theory?</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>Jan H. van Schuppen</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Team Theory and Information Structures of Stochastic Dynamic Decentralized Decision</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>C.D. Charalambous and N.U. Ahmed</td>
<td></td>
</tr>
</tbody>
</table>
20 Signaling of Information ........................................ 165
César A. Uribe and Jan H. van Schuppen

21 Distributed Control of Manufacturing Networks:
Analysis of Performance ........................................ 173
Konstantin K. Starkov, Alexander Y. Pogromsky
and Jacobus E. Rooda

Part V Distributed Control with Communication

22 What Is Distributed Control with Direct Communication
Between Controllers? .......................................... 183
Jan H. van Schuppen

23 Communication Constraints in Control and Observation
of Distributed Systems .................................... 191
A.Yu. Pogromsky and A.S. Matveev

24 Information Structures .................................... 197
Jan H. van Schuppen

25 Control Theory with Information Structures ............. 205
Jan H. van Schuppen

26 Common, Correlated, and Private Information
in Control of Decentralized Systems .................... 215
Jan H. van Schuppen

27 Distributed State Estimation with Communication
of Observations .............................................. 223
André C.M. Ran and Jan H. van Schuppen

Part VI Multilevel Control

28 Complexity and Scalability of Hierarchical Control
for Networked Infrastructures ............................... 231
Jos Vrancken

29 Hierarchical Control for Road Traffic Management ....... 239
Jos Vrancken
Part VII  Communication and Control of Distributed Systems

30  Layered Backpressure Scheduling for Delay-Aware Routing in Ad Hoc Networks ........................................... 251  
Dimitrios Katsaros

31  Cache Control Issues in Pub–Sub Networks and Wireless Sensor Networks ............................................. 259  
Dimitrios Katsaros

32  Detecting Influential Nodes in Complex Networks with Range Probabilistic Control Centrality .......... 265  
Dimitrios Katsaros and Pavlos Basaras

33  Model Predictive Controllers over Differentiated Services Packet Networks ........................................... 273  
Riccardo Muradore, Davide Quaglia and Paolo Fiorini

34  A SystemC/MATLAB Co-simulation Tool for Networked Control Systems ............................................. 283  
Davide Quaglia, Riccardo Muradore and Paolo Fiorini

35  On Shannon’s Duality of a Source and a Channel and Nonanticipative Communication and Communication for Control ........................................... 291  
Charalambos D. Charalambous, Christos K. Kourtellaris and Photios A. Stavrou

36  Directed Information on Abstract Spaces: Properties and Extremum Problems ........................................... 307  
Charalambos D. Charalambous, Photios A. Stavrou and Christos K. Kourtellaris

37  Information Nonanticipative Rate Distortion Function and Its Applications ........................................... 317  
Photios A. Stavrou, Christos K. Kourtellaris and Charalambos D. Charalambous

38  Nonanticipative Duality of Sources and Channels with Memory and Feedback ........................................... 325  
Christos K. Kourtellaris, Charalambos D. Charalambous and Photios A. Stavrou
Part VIII Informatics of Distributed Systems: Modeling and Verification

39 An Introduction to the Verification of Hybrid Systems
Using Ariadne .............................................. 339
Davide Bresolin, Luca Geretti, Tiziano Villa and Pieter Collins

40 Formal Verification Applied to Robotic Surgery .............. 347
Davide Bresolin, Luca Geretti, Riccardo Muradore,
Paolo Fiorini and Tiziano Villa

41 Computing Reachable Sets of Differential Inclusions ........... 357
Sanja Živanović Gonzalez and Pieter Collins

42 Modeling Objects Moving in a Complex Environment
with World Automata ........................................ 367
Marta Capiluppi and Roberto Segala

43 Distributed Average Consensus in Digraphs ...................... 375
Christoforos N. Hadjicostis and Alejandro D. Dominguez-García

Part IX Research Program

44 Research Program for Control of Distributed
and of Multilevel Systems .................................... 385
Jan H. van Schuppen

Index ................................................................. 393