

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Discrete Event Systems (DES)	2
1.3	Bosch Mechatronics System (BMS)	4
1.4	Contribution	6
1.5	Organization	8
2	Automatic Modeling and Fault Diagnosis Challenges	9
2.1	Fault Diagnosis of DES	9
2.1.1	Terms	9
2.1.2	Concepts	11
2.2	Model-based Fault Diagnosis Challenges	13
2.3	Modeling Challenges	14
3	Identification of Timed Distributed DES Models	19
3.1	Preliminaries	19
3.2	Timed Modeling	20
3.2.1	Internal and External Behavior	20
3.2.2	Timed Model and Languages	23
3.3	Identification of Timed Models	32
3.3.1	Time Identification Approach	32
3.3.2	Timed Identification Algorithm	35
3.3.3	Precision and Completeness Properties	41
3.3.4	Identification Parameters	43
3.4	Timed Distributed Modeling	44
3.5	Identification of Timed Distributed Models	49
3.5.1	Timed Distributed Identification Approach	49
3.5.2	Precision and Completeness Properties	50
3.5.3	Discussion on Shared I/Os	54
3.6	Identification of Timed Distributed BMS Models	57
3.6.1	Data Collection	57
3.6.2	Timed Distributed Identification	59

4	Partitioning of DES Models	67
4.1	Preliminaries	67
4.2	Causal Partitioning	69
4.2.1	Distance and Causality	69
4.2.2	Causal Partitioning Algorithm	75
4.3	Optimal Partitioning	78
4.3.1	Optimization Approach	78
4.3.2	Optimal Partitioning Algorithm	81
4.4	Partition Synthesis	84
4.5	Partitioning of BMS Models	86
4.5.1	Causal Partitioning	86
4.5.2	Optimal Partitioning	88
4.5.3	Partition Synthesis	90
5	Fault Detection and Isolation using Timed Distributed DES Models	93
5.1	Preliminaries	93
5.2	Evaluation	94
5.3	Timed Fault Detection	97
5.4	Timed Fault Isolation	100
5.4.1	Preliminaries	100
5.4.2	Deadlock Behavior	101
5.4.3	Early and Late Behavior	102
5.5	Extension to Timed Distributed Models	104
5.5.1	Overview	104
5.5.2	Distributed Evaluation	105
5.5.3	Distributed Fault Detection and Isolation	106
5.6	Fault Detection and Isolation of the BMS	109
5.6.1	Online Fault Diagnosis Implementation	109
5.6.2	Fault Scenarios	110
5.6.3	Model Validation	115
6	Related Works – Analysis and Comparison	121
6.1	Modeling of Timed DES	121
6.1.1	Language Model	121
6.1.2	Automaton Model	122
6.1.3	Petri Net Model	124
6.1.4	Discussion	126
6.2	Identification of DES Models	127
6.2.1	Preliminaries	127
6.2.2	Identification of Logical Models	128
6.2.3	Identification of Timed Models	129
6.2.4	Discussion	136
6.3	Automatic Modeling of Concurrent DES	138
6.3.1	Preliminaries	138

6.3.2	Probabilistic Data Mining	138
6.3.3	Model Optimization	140
6.3.4	Discussion	143
6.4	Model-based Fault Diagnosis of DES	144
6.4.1	Preliminaries	144
6.4.2	Fault Diagnosis using Logical Models	145
6.4.3	Fault Diagnosis using Timed Models	151
6.4.4	Discussion	155
7	Conclusion	157
7.1	Summary	157
7.2	Further Work	159
8	Kurzfassung in deutscher Sprache (extended summary in German)	161
	Appendix A Proofs	167
	Appendix B Example Shared I/Os	171
	Nomenclature	173
	Bibliography	179