

Agent-based simulation of transportation nodes

Assoc. Prof. Antonín Kavička, PhD.

*Jan Perner Transport Faculty
University of Pardubice, Czech Republic*

Assoc. Prof. Valent Klima, PhD.

Ing. Norbert Adamko

*Faculty of Management Science and Informatics
University of Žilina, Slovak Republic*

Contents

INTRODUCTION	3
1 SERVICE SYSTEM OF A MARSHALLING YARD	9
1.1 BASIC RAILWAY TERMINOLOGY	9
1.2 MARSHALLING YARD AS A SERVICE (QUEUING) SYSTEM.....	13
2 SIMULATION	19
2.1 BASIC TERMINOLOGY	19
2.2 ALGORITHMISATION OF SIMULATION MODELS	27
2.3 SIMULATION PROJECT	31
2.4 WHERE APPLY SIMULATION?	42
3 SIMULATION MODEL ARCHITECTURE	43
3.1 MOTIVATION	43
3.2 AGENT PARADIGM	44
3.3 REACTIVE AGENTS.....	47
3.4 WHY AGENTS AND SIMULATION?	48
3.5 AGENT-BASED ARCHITECTURE OF SIMULATION MODELS	49
3.5.1 <i>Decomposition of an agent</i>	52
3.5.2 <i>Multiagent approach</i>	53
3.5.3 <i>MPE/ABAsim tier model</i>	55
3.5.4 <i>Communication mechanism</i>	56
4 SYNCHRONISATION OF SIMULATION EXECUTION	61
4.1 SYNCHRONISATION OF DISCRETE SIMULATION.....	61
4.2 COMBINED SIMULATION INCLUDING ON-LINE ANIMATION	65
4.2.1 <i>Structure of combined simulation model with animator</i>	67
4.2.2 <i>Synchronisation of simulation modules</i>	68
4.2.3 <i>Continuous simulation module</i>	69

4.2.4	<i>Interface module</i>	71
4.2.5	<i>Animation module</i>	71
5	DESCRIPTION OF AGENT COMPONENTS USING PETRI NETS.....	75
5.1	DEFINITION OF P/T PETRI NETS	75
5.2	DECISION ABA-GRAPH.....	82
5.2.1	<i>Marked graph</i>	82
5.2.2	<i>ABA-graph</i>	83
5.2.3	<i>Characteristics of ABA-graph in ABAsim architecture</i>	88
5.2.4	<i>Notes to ABA-graph implementation</i>	89
5.3	ILLUSTRATION OF ABA-GRAPH APPLICATION.....	91
5.4	UTILISATION OF COLOURED PETRI NETS	96
6	SIMULATION MODEL OF A MARSHALLING YARD	99
6.1	REQUIREMENTS FOR SIMULATION MODEL	99
6.2	SPECIFICATION OF A MARSHALLING YARD SYSTEM.....	102
6.2.1	<i>Service resources</i>	102
6.2.2	<i>Technological procedures</i>	103
6.2.3	<i>Trains and wagons</i>	106
6.2.4	<i>Management</i>	107
6.3	CONCEPTUAL MODEL	109
6.4	SIMULATION MODEL	111
6.4.1	<i>Agent Railway Network</i>	112
6.4.2	<i>Agent Dispatcher</i>	113
6.4.3	<i>Agent Technology</i>	114
6.4.4	<i>Agent Sorting</i>	117
6.4.5	<i>Agent Simultaneous sorting</i>	117
6.4.6	<i>Agent Compression</i>	117
6.4.7	<i>Agent Trackage</i>	117
6.4.8	<i>Agent Locomotives</i>	120
6.4.9	<i>Agent Personnel</i>	121
6.4.10	<i>Agent Transfer</i>	121
6.5	SIMULATION EXPERIMENTS AND RESULTS EVALUATION.....	122
6.5.1	<i>Philosophy of simulation experiments</i>	122
6.5.2	<i>Types of problems suitable to be solved using simulation model of a marshalling yard</i>	127
6.5.3	<i>Experiment scenario and simulation model parametrisation</i>	129
6.5.4	<i>Evaluation of simulation results</i>	133
7	EXAMPLE OF SIMULATION MODEL IMPLEMENTATION	135
7.1	LOCOMOTIVE REPAIR SHOP.....	135

7.2	DESCRIPTION OF REPAIR SHOP OPERATION	135
7.3	ANALYSIS AND SYSTEM DEFINITION.....	136
7.4	CONCEPTUAL MODEL.....	138
7.5	AGENT TASKS AND THEIR COMPONENTS	141
7.6	IMPLEMENTATION OF THE SIMULATION MODEL	144
8	CONCLUSIONS.....	187
	REFERENCES.....	191
	EXPLANATION OF MATHEMATICAL SYMBOLS	199
	INDEX.....	201