Hybrid Petri Nets
a Framework for Hybrid Systems Modeling

Mircea Adrian Drighiciu
University of Craiova
Department for Electromechanics, Environment and Applied Informatics
Craiova, Romania
adrighiciu@em.ucv.ro

Abstract— **The purpose of this paper is to present the achievement of the Hybrid Petri Nets techniques used for modeling and behavioral analysis of a class of hybrid systems. In our sense, a dynamic hybrid system contains at least two distinct subsystems which interact: a continuous subsystem (linear, or not) and a discrete subsystem with a finite number of states. In this context, after a brief introduction to the basic elements of Hybrid Petri Nets modeling, two hybrid systems, consisting of liquid level control of one and two interconnected tanks were analyzed in different specific scenarios. The analysis starts with the synthesis of a Hybrid Petri Net model for each system, followed by their refinement and validation by simulation of their behavioral properties, in order to achieve and implement a command - control structure (the sequential controller) of the process. For the models synthesis and for their validation, Visual Object Net++ tool was used.**
Keywords— **hybrid systems; Petri Nets; modeling; simulation**

REFERENCES

[1] P.J. Antsalkis, W. Khone, A. Nerode, S. Sastry (Coordinators), "Hybrid Systems II", Lecture Notes in Computer Science, 999, Springer-Verlag, 1995.

[2] P. J. Antsalkis, J. A. Stiver, M. D. Lemmon, "Hybrid System Modeling and Autonomous Control Systems", Workshop on Theory of hybrid Systems, Lecture Notes in Computer Science 736, Springer-Verlag, pp.336-392, 1993.

[3] M. S. Branicky , "A Unified Framework for Hybrid Control", Proc. 33rd Conference on Decision and Control, Lake Buena Vista, Fl., USA, pp. 4228 – 4234, 1994.

[4] B. Cébron, Commande de systèmes dynamiques hybrides - Thèse, Université d'Angers, France, 2000.

[5] R. David, H. Alla, "On Hybrid Petri Nets", Discrete Event Dynamic Systems: Theory and Applications, 11, 2001, pp. 9 – 40.

[6] R. David, H. Alla, "Discrete, Continuous and Hybrid Petri Nets", Springer-Verlag 2005.Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[7] I. Demongodin, N. T. Koussoulas, "Modelling of hybrid control systems using Petri nets", (Zaytoon, 1998), pp.330 – 337, 1998.

[8] I. Demongodin, F. Prunet, "Batch Petri Nets", Proceedings of 7th Annual European Computer Conference, Paris, 1993, p.29 – 37.

[9] R. Drath, "Objektorientierte Modellierung hybrider Prozesse – Vorstellung eines neuen Werkzeuges", IWK , 42, pp. 533 – 540, 1997.

[10] R. Drath, Tool Visual Object Net ++, Available at: http://www.daimi.au.dk/PetriNets/tools.

[11] R. Drath, "Hybrid Object Nets: An Object Oriented Concept for Modelling Complex Hybrid Systems", Dynamical Hybrid Systems, ADPM98, Reims, 1998.

[12] M. A. Drighiciu, D. C. Cismaru, "Hybrid Petri Nets in Modeling the Packing Processes: Case Study", Annals of the University of Craiova, Electrical Engineering series, No. 39, 2015; ISSN 1842-4805, pp.93 – 100.

[13] M. A. Drighiciu, "Petri Net formalism for a possible hierarchical structure of complex hybrid systems", Proceedings of 6th International Carpathian Control Conference, Miskolc – Lillafüred, Hungary, pp. 371-376, 2005.

[14] M. A. Drighiciu, Gh. Manolea, D. C. Cismaru, Anca Petrişor, "Hybrid Petri Nets as a New Formalism for Modeling Electrical Drives", Proceedings of International Symposium on Power Electronics, Electrical Drives, Automation and Motion – SPEEDAM 2008, ISBN: 978-1-4244-1664-6, IEEE Catalog Number: CFP0848A-CDR, Ischia, Italy, 11th – 13th June, pp.626-631, 2008.

[15] M. A. Drighiciu, Gh. Manolea, Anca Petrisor, M. C. Popescu, "On Hybrid Systems Modeling with Petri Nets", Recent Advances in System Science and Simulation in Engineering, Proceedings of the 7th WSEAS International Conference on System Science and Simulation in Engineering (ICOSSSE'08), Venice , 21- 23 November, pp.73-78, 2008.

[16] M.A. Drighiciu, Anca Petrişor, " A Modified Petri Net Framework for Hybrid Systems Modeling", Analele Universităţii din Craiova; Seria Inginerie Electrică, Anul 35, No.35, ISBN:1842-4805, Editura Universitaria Craiova, pp.158-165.

[17] E. Dubois, "Continuous Petri net with maximal speeds depending on time", Proc.Of 15th International Conference on Application and Theory of Petri Nets, Zaragoza, Spain, 1994.

[18] S. Engell, G. Frehse, E. Schneider (Coordinators), "Modelling, Analysis, and Design of Hybrid Systems", Lecture Notes in Control and Information Sciences 279, Springer-Verlag, 2002, ISBN: 3-540-43812-2, pp.3-36.

[19] Maria Pia Fanti, G. Iacobellis, A. M. Mangini, "Freeway Traffic Modeling and Control in a First-Order Hybrid Petri Net Framework", IEEE Transactions on Automation Science and Engineering, Volume 11, Issue: 1, Jan. 2014, pp.90 – 102.

[20] J. M. Flaus, "Hybrid flow nets for batch processes modelling and simulation"' Proceedings of 2nd IMACS MATHMOD Conference, Viena, 1997, p.211 – 216.

[21] R. L. Grosmman, "Hybrid Systems", Lecture notes in ComputerScience, Springer, New York, Vol.736, 1993.

[22] X. Lu, M.C. Zhou, A. C. Ammari, J.Ji, " Hybrid Petri Nets for Modeling and Analysis of Microgrid Systems", IEEE/CAA , Journal of Automatica SINICA, Vol. 3, No. 4, October 2016, pp 349 – 356.

[23] L. A. M. Riascos, L. A. Moscato, P.E. Miyagi, "Detection and Treatment of faults in Manufacturing Systems based on Petri Nets", Journal of the Brazilian Soc.of Mech.Sci.&Eng., Vol.XXVI, No.3, July– September, 2004, p.280 – 289.

[24] A. T. Sava, H. Alla, "Combining Hybrid Petri Nets and Hybrid Automata", IEEE Transaction on Robotics and Automation, Vol.17, No.5, October 2001, p.670 – 678.

[25] C. Valentin-Roubinet, "Hybrid Dynamic System verification with Mixed Petri Nets", The 4th International Conference on Automation of Mixed Processes: Hybrid Dynamic System, Dortmung, Shaker Verlag, Aachen, pp.231-236.

[26] Emilia Villani, P. E. Miyagi, R. Valette, Modelling and Analysis of Hybrid Supervisory Systems; a Petri Net Approach, Springer-Verlag, 2007, ISBN 978-1-84628-650-6, pp. 1-13.

[27] J. Zaytoon (Coordinator), Systèmes dynamiques hybrides , Hermes-Science, 2001.

[28] A. Zimmermann, G. Hommel, "Modeling and evaluation of manufacturing systems using dedicated Petri nets", International Journal of Advanced Manufacturing Technologies No.15(2),p.132–138.