University of Florence

PhD in Smart Computing
XXXII cycle

Progress Report

first year

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Research topics: Model-based quantitative analysis for on-line diagnosis, prediction, scheduling and compliance evaluation in partially observable systems
Advisor: Prof. Enrico Vicario
Supervisory committee: Dr. Mieke Massink, Prof. Mirco Tribastone

Research and results

In this section, the main research conducted and the most relevant results will be shown. The main topic of the PhD research is that of model-based quantitative analysis, especially in the scenario of partially observable systems.

Before the start of the first year of the PhD, a period of five months as a Research Fellow at University of Florence has been conducted, during which, under the supervision of Prof. Enrico Vicario, research activity has been started, following the same topics. In particular, during this period we produced the conference paper [10], which focused on the performance evaluation of a mutual exclusion protocol (the Fischer's protocol) exploiting a technique for steady-state evaluation of Markov Regenerative Processes (MRP) [9]. Part of this work was also the implementation of the steady-state technique for MRPs described in [9] exploiting the APIs of the Oris tool [5].

The PhD period started with the investigation and implementation of a technique for the transient analysis of MRPs under *enabling restriction*, which characterises all those MRPs that have, at any given time, at most one GEN (GENerally distributed transition) . In particular, the technique implemented has been studied from [6] and implemented through the Oris tool APIs.

During the first year of the PhD the LINFA (Logistica INtelligente del FArmaco) project has also been followed. The LINFA project is a regional project funded by the Tuscany region that aims to develop a software for decision support for hospital staff members for drugs restocking. Drugs restocking can in fact be a hard and expensive process and by exploiting data processing and forecasting technique it can be made easier and cheaper. For this reason, techniques for model-based forecasting and decision support has been investigated. In particular, techniques that exploit Markov Decision Processes (MDP) [1] has been investigated and later implemented through the PRISM model checking tool [8] and a Java framework that generates an actualised PRISM model each time a drugs restock has to be issued, following the idea of *models@runtime* [4].

A compositional technique for transient analysis of MRPs has then been investigated. The idea was to combine both the technique for transient analysis of MRPs under enabling restriction shown in [6] and the technique for transient analysis of MRPs under *bounded regeneration*, which characterises all the MRPs that has no cycles between any two regenerations, shown in [7], exploiting non-deterministic analysis. In particular, this compositional technique would first perform non-deterministic analysis on an MRP for each of its regenerations and classify them depending on which of the two conditions (enabling restriction and bounded regeneration) are satisfied. Depending on the result of this classification, the correct transient technique would then be applied to compute local and global kernels for that specific regeneration epoch, exploiting the fact that kernel rows, corresponding to different regenerative epochs, can be evaluated independently and thus with different techniques. When the whole local and global kernels have been computed, transient solution can be evaluated through the evaluation of Markov renewal equations. In order to evaluate those regenerations where none of the two conditions are satisfied, approximate evaluation has also been studied: the approximate technique investigated is based on the technique shown in [7] and implements a guided transient analysis in order to explore first the "most relevant" transient classes. Results of this work have been published in [2].

Courses attended

The following section reports a list of exams passed, seminars, tutorials, or summer schools attended. The Smart Computing PhD programme requires at least 9 credits by the end of the first year and at least 18 credits at the end of the second year.

Exams

- **GPU Programming Basics** (Marco Bertini, UniFi): 3 credits
- **Fuzzy Logic & Fuzzy Systems** (Beatrice Lazzerini, UniPi): 3 credits

Seminars

- **ProPPA: Probabilistic Programming Process Algebra** (Anastatis Georgoulas, IMT Lucca): ??? credits
- **Modelling, analysis and design of cyber-physical systems** (Ezio Bartocci, UniFi): 0.5 credits

Summer schools

- **Summer School on Optimization, Big Data and Applications (OBA)** (Veroli, Italy): 5 credits

Current total credits

The number of current total credits achieved by the end of the first year of PhD is 11.5.

Publications

The followings are all the published papers:

- **Title:** Performance Evaluation of Fischer's Protocol through Steady-State Analysis of Markov Regenerative Processes [10]
  Authors: Stefano Martina, Marco Paolieri, Tommaso Papini, Enrico Vicario
  Conference: Modeling, Analysis and Simulation of Computer and Telecommunication Systems, MASCOTS 2016

- **Title:** Exploiting Non-deterministic Analysis in the Integration of Transient Solution Techniques for Markov Regenerative Processes [2]
  Authors: Marco Biagi, Laura Carnevali, Marco Paolieri, Tommaso Papini, Enrico Vicario
  Conference: International Conference on Quantitative Evaluation of Systems, QEST 2017

- **Title:** An Inspection-Based Compositional Approach to the Quantitative Evaluation of Assembly Lines [3]
  Authors: Marco Biagi, Laura Carnevali, Tommaso Papini, Kumiko Tadano, Enrico Vicario
  Conference: European Workshop on Performance Engineering, EPEW 2017

Conferences and workshops

The followings are all the conferences and workshops attended:

- **International Conference on Quantitative Evaluation of Systems** (QEST 2017), Berlin (Germany), September 5-7 2017
- **European Workshop on Performance Engineering** (EPEW 2017), Berlin (Germany), September 7-8 2017
- **International Workshop on Practical Applications of Stochastic Modelling** (PASM 2017), Berlin (Germany), September 9 2017

Research visits to external institutions

Research plan for the next year

References

[1] Bellman, R. A Markovian decision process. *Journal of Mathematics and Mechanics* (1957), 679–684.

[2] Biagi, M., Carnevali, L., Paolieri, M., Papini, T., and Vicario, E. Exploiting Non-deterministic Analysis in the Integration of Transient Solution Techniques for Markov Regenerative Processes. In *International Conference on Quantitative Evaluation of Systems* (2017), Springer, pp. 20–35.

[3] Biagi, M., Carnevali, L., Papini, T., Tadano, K., and Vicario, E. An Inspection-Based Compositional Approach to the Quantitative Evaluation of Assembly Lines. In *European Workshop on Performance Engineering* (2017), Springer, pp. 152–166.

[4] Blair, G., Bencomo, N., and France, R. B. Models@ run. time. *Computer 42*, 10 (2009).

[5] Bucci, G., Carnevali, L., Ridi, L., and Vicario, E. Oris: a tool for modeling, verification and evaluation of real-time systems. *International Journal on Software Tools for Technology Transfer (STTT) 12*, 5 (2010), 391–403.

[6] German, R., Logothetis, D., and Trivedi, K. S. Transient analysis of Markov regenerative stochastic Petri nets: A comparison of approaches. In *Petri Nets and Performance Models, 1995., Proceedings of the Sixth International Workshop on* (1995), IEEE, pp. 103–112.

[7] Horváth, A., Paolieri, M., Ridi, L., and Vicario, E. Transient analysis of non-Markovian models using stochastic state classes. *Performance Evaluation 69*, 7 (2012), 315–335.

[8] Kwiatkowska, M., Norman, G., and Parker, D. PRISM 4.0: Verification of Probabilistic Real-time Systems. In *Proc. 23rd International Conference on Computer Aided Verification (CAV'11)* (2011), G. Gopalakrishnan and S. Qadeer, Eds., vol. 6806 of *LNCS*, Springer, pp. 585–591.

[9] Logothetis, D., Trivedi, K. S., and Puliafito, A. Markov regenerative models. In *Computer Performance and Dependability Symposium, 1995. Proceedings., International* (1995), IEEE, pp. 134–142.

[10] Martina, S., Paolieri, M., Papini, T., and Vicario, E. Performance Evaluation of Fischer's Protocol through Steady-State Analysis of Markov Regenerative Processes. In *Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS), 2016 IEEE 24th International Symposium on* (2016), IEEE, pp. 355–360.