Title of the Proposal:
Using IOPT-Tools for Petri nets driven controller development

Presenter(s):
Prof. Luis Gomes, NOVA University Lisbon, Portugal, lugo@fct.unl.pt

Brief description:
The lack of tools ready to be integrated in engineering development frameworks are one major
drawback when considering Petri nets usage within specific areas of application. This tutorial
addresses usage of a model-driven development approach using Petri nets as the underlying
modeling formalism. The tutorial is divided into two parts, being the first one more on Petri nets
fundamentals and their usage for controller modeling and implementation, while the second one
emphasizes on the development of controllers for embedded and/or cyber-physical systems. Both
parts rely on the support from the IOPT-Tools framework, complemented by hands-on
experimentation using IOPT-Tools for the development of controllers.
The IOPT-Tools web-based framework provides support for the complete development flow for
cyber-physical systems and embedded systems, offering tools for engineers as well as for academics,
including editor, simulator, remote debugger, and property verification tools. Rapid-prototyping is
fully supported, allowing automatic code generation ready to be directly deployed in different types
of platforms, ranging from FPGAs (where VHDL code is produced) to popular low-cost boards, such
as Arduino and Raspberry Pi (where C code is produced), and also including PLCs (through
Instruction List generation). The IOPT-Tools framework is publicly available at

Petri nets main characteristics and classes are presented, including firing semantics and common
execution semantics (namely interleaving semantics used in most simulation environments, as well
as maximal step semantics used in most control applications), net operations (namely addition and
splitting), and proprieties verification techniques (namely formal techniques based on invariants and
state space exploration). The tutorial will cover situations where a centralized execution is used, as
well as others were distributed execution is the goal.

A few application examples will be used to illustrate the application of the referred tool framework
in the development of different kinds of systems and implementation platforms (ranging from
industrial PCs, RaspberryPi, Arduinos, and FPGAs).

Attendees are welcome to bring their own portable computers or smart phones to play with IOPT-
Tools.

Duration: 2 hours

Outline:
Motivation to move towards model-driven controller development
Looking back
The productivity gap
The verification gap
The performance gap
Open issues and challenges
Moving to model-driven development
Selection of modelling formalisms

Petri nets
  Introduction
  Firing rules
  Main modeling characteristics
  Petri nets classes
    Low-level vs high-level Petri nets
    Autonomous vs non-autonomous Petri nets
  Considerations on operational semantics
  Application example
  Algebraic representation
  Property verification techniques
    Behavioral vs structural properties
    State space construction
    Invariants
  Petri nets for controller modelling
  The Input-Output Place-Transition Petri nets class (IOPT-nets)

IOPT-Tools - Petri nets tools for controller development
  Development flow
  Brief presentation of main tools
    Model editor
    Simulator
      Token-player simulator
      Timing diagrams
    Remote debugger
    State-space generator
    Query editor and query results
    Automatic code generation
      C code
      VHDL code
  Implementation platforms
    Software platforms (Arduino, Raspberry, ESP, Linux-based)
    Hardware platforms (FPGAs)
  Application example
  Demo and hands-on experimentation

- **Motivation and Focus:**
  This tutorial is about to develop controllers for embedded and cyber-physical systems emphasizing the benefits from adoption of a model-driven approach. For that end, Petri nets modelling is proposed and a web-based development framework (the IOPT-Tools) is presented. Petri nets benefit from a strong theoretical body of knowledge as well as from tool support addressing all phases of developing of controllers. Whenever dependable or critical systems are needed, the capability to perform property verification, complementing simulation results, as well as to rely on tools for controller design
automation is of paramount importance. Petri nets modelling and IOPT-Tools can contribute to that answer.

During the tutorial the capabilities of IOPT-Tools will be presented, namely supporting simulation and verification of models, as well as to automatically generate implementation code, in C or VHDL, which can be directly deployable in common implementation platforms (and produce controller’s execution code without writing a line of code). Low-cost platforms, such as Arduino and Spartan FPGA boards, will be used for hands-on practice during the tutorial.


Brief CV:

Luis Gomes received his Electrotech. Eng. Degree from Technical University of Lisbon, Portugal, in 1981, and a PhD degree in Digital Systems from Universidade Nova de Lisboa, Portugal, in 1997. He is a professor at the Electrical and Computer Engineering Department, Faculty of Sciences and Technology of NOVA University Lisbon, Portugal and a researcher at UNINOVA Institute, Portugal. From 1984 to 1987, he was with EID, a Portuguese medium enterprise, in the area of electronic system design, in the R&D engineering department. His main interests include the usage of Petri nets and other models of concurrency, applied to reconfigurable and embedded systems co-design and cyber-physical systems. He was made Honorary Professor of Transilvania University of Brasov, Brasov, Romania, in 2007, as well as Honorary Professor of Óbuda University, Budapest, Hungary, in 2014. He has received the IEEE Industrial Electronics Society Anthony J Hornfeck Service Award in 2016. Dr. Gomes is author/co-author of more than 200 papers and chapters published in journals, books and conference proceedings, as well as co-author of one book and co-editor for three books.

Relevant publications:

Maximally 5 publications including edited books


“Asynchronous-channels within Petri net based GALS distributed embedded systems modeling”; Filipe Moutinho, Luís Gomes; IEEE Transactions on Industrial Informatics; Vol.10 Issue: 4; Nov. 2014; pp 2024-2033; ISSN: 1551-3203; DOI: 10.1109/TII.2014.2341933

“The IOPT-Flow modeling framework applied to Power Electronics controllers”; Fernando Pereira, Luís Gomes; IEEE Transactions on Industrial Electronics; Volume: 64, Issue: 3, March 2017, Page(s): 2363 – 2372; Date of Publication: 21 October 2016, DOI: 10.1109/TIE.2016.2620101