INTO-CPS PROJECT FACTS

Title:
Integrated Tool Chain for Model-based Design of Cyber-Physical Systems

Project Partners:
Aarhus University, Denmark
Newcastle University, UK
University of York, UK
Linköping University, Sweden
Verified Systems International, Germany
Controllab Products, Netherlands
ClearSy, France
TWT GmbH - Science & Innovation, Germany
Agro Intelligence, Denmark
United Technologies, Ireland
Softeam, France

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Project Website: www.into-cps.au.dk

Duration: 36 months (2015-2017)

What is INTO-CPS

Systems composed of closely coupled computing and physical elements are increasingly important in the modern world. Such Cyber-Physical Systems (CPSs) are characterised by a complex architecture and a design process involving different science and engineering disciplines. At the interface between disciplines, different formalisms and technical cultures meet, and the traditional approaches for designing systems vary significantly among the relevant fields. The developer of a CPS faces a large design space that is difficult to cover with hardware prototypes due to the high cost of their implementation. A common workflow for the model-based design of CPS – and the necessary tools – is currently missing.

To address these challenges, INTO-CPS seeks to create an integrated "tool chain" for comprehensive model-based design of CPSs. The tool chain will support multidisciplinary, collaborative modelling of CPSs from requirements, through simulation of multiple heterogeneous models that represent the physical elements as well as the computational parts of the system, down to realisation in hardware and software, enabling traceability at all stages of the development.

Project progress: FMI support

One of the basic technological standards that INTO-CPS builds upon is the Functional Mock-up Interface (FMI) (www.fmi-standard.org). This is a standard for exchanging simulation models consisting mainly of two parts: (1) the description of the model interface, listing the input and output signals (such as flows, forces, current, etc.) that are exchanged between models and (2) the model itself that is enclosed in the Functional Mock-up Unit (FMU) with a solver, either as source code or as binary file. For coupling of multiple models in a Co-simulation, the models need to be exported from their native tools first.

Recently, progress was made with respect to FMU export from the INTO-CPS modelling tools, 20-sim and OpenModelica for physical modelling and Overture for event-based modelling. These three tools now support the latest FMI 2.0 specification and allow exporting

of models as a stand-alone FMU. This is an important requirement for building a tool-chain since the models can then be combined together in a Co-Simulation framework as indicated in Figure 1.

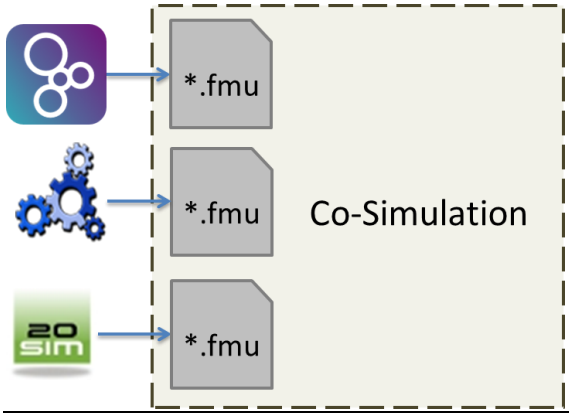

Figure 1. Exporting models from Overture, OpenModelica and 20-sim as FMU, and combining them in a Co-Simulation.

Spotlight on a Case study: Railways

The railway case study is provided by the French company Clearsy and is focused on the modelling, design and analysis of the automatic train protection - mainly interlocking and safe braking mechanisms. The trains and track map can be seen in Figures 2 and 3.

Figure 2. Tramway controlled by Clearsy's products.

The protection of trains is based on the coherent locking of the switches and traffic lights (interlocking) together with the monitoring of train speed, the next authorised limit position and the prediction of the worst braking behaviour of the train (safe braking).

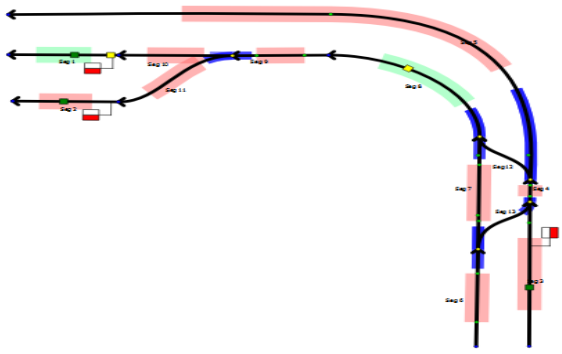

Figure 3. Track map, evolving train traffic and interlocking signals

The system presents many technical challenges both from the methodological and the technical point of view. The application of the INTO-CPS tool chain will allow several gains and improvements to Clearsy's work.

The cost of "on-site tests and back to redesign" will be reduced by finding bugs at the design stage using cyber-physical co-simulations. Already now, bugs in the software can be found at an early stage using the INTO-CPS tools.

Furthermore, it will be possible to find optimised parameters for increasing train traffic. This will allow Clearsy to find the right zone decomposition for an optimal distributed interlocking. Furthermore, safe braking parameters can be defined that keep a safe but decreased distance to other trains based on Co-simulations.

Finally, confidence can be gained concerning the safety performance of the whole cyber physical system described by

multi-models. This is enabled by simulating the interlocking algorithm in real time, the distributed hardware running the algorithms, the delayed switches or relay behaviours, the track circuits and telecommand beacons behaviour, the "real" train's movements on the track map.

Call for challenges

As the INTO-CPS tools start forming a toolchain, and much work has already been done to lay the foundations, we would like to invite the members of the Industrial Follower Group (IFG) to submit challenges for modelling. This will allow the companies providing the pilot studies to have access to the latest INTO-CPS tools and to have experts from academia and industry model their problems with state-of-the-art tools and methods.

These challenges should be a Cyber-Physical System from a real application that fits into the scope of INTO-CPS and that can be modelled with the INTO-CPS tools and methods.

The selected challenges will be, at least partially, made public as a showcase for the INTO-CPS technologies.

For more information on the challenges, please contact Ken Pierce or Carl Gamble from the University of Newcastle (kenneth.pierce@newcastle.ac.uk and carl.gamble@newcastle.ac.uk).

IFG webinar and workshop

To demonstrate the capabilities of the INTO-CPS tools, we are planning several webinars and workshops in 2016.

For the first webinar, focused on the automotive industry, we would like to invite interested IFG members. The webinar will take place on Friday 22 April 2016 at 10 am (CET). There will be a presentation of the status of INTO-CPS and of how to use the tools for different tasks in the development of automotive CPS, as well as a Q&A session.

In addition, there will be a face-to-face workshop in Linköping (Sweden) on 14 June 2016. It will be held in conjunction with the INTO-CPS plenary meeting, so it gives IFG members from the region the chance to discuss with the INTO-CPS developers and experience the tools first-hand.

If you are interested in any of these events, please send an e-mail to Peter Gorm Larsen (pgl@eng.au.dk) or Christian König (christian.koenig@twt-gmbh.de).

Upcoming events

CPS data workshop

In conjunction with CPS week, a workshop on "CPS Data – 2nd International Workshop on modeling, analysis and control of Cyber-Physical Systems" will be held on 11 April 2016 in Vienna, Austria. This workshop will be co-organised by INTO-CPS partners. For more information, please visit the website:

https://www.twt-gmbh.de/cpsdata.html

Recent Publications

P. G. Larsen and J. Fitzgerald, *The Evolution of VDM Tools from the 1990s to 2015 and the Influence of CAMILA*, Journal of Logical and Algebraic Methods in Programming

L. D. Couto, P. G. Larsen, M. Hasanagic, G. Kanakis, K. Lausdahl and P. W. V. Tran-Jørgensen, *Towards Enabling Overture as a Platform for Formal Notation IDEs*, 2nd Workshop on Formal-IDE, Oslo, Norway, June 2015

M. P. Christiansen, P. G. Larsen and R. N. Jørgensen, *Robotic Design Choice Overview Using Co-Simulation and Design Space Exploration*, Robotics 2015, 4, 398-421; doi:10.3390/robotics4040398

A. Cavalcanti, W.-L. Huang, J. Peleska, and J. Woodcock, *Unified Runtime Verification for CSP*, 12th International Colloquium on Theoretical Aspects of Computing, October 29-31, 2015.

For more updates, visit our website:

http://into-cps.au.dk/