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: Co-simulation and user interface

After we have introduced, in previous newsletters, the FMU generation of the modelling tools (Newsletter #2) and the SysML modelling (Newsletter #3), we are now giving an overview of a central part of INTO-CPS which connects the different tools:

A **Co-Simulation** orchestration engine (COE) was created that organises the exchange of simulation results between the single models. Figure 1 shows a simplified scheme of the interaction. The single tools export their models as encapsulated files in the Functional Mock-up Unit (FMU), following the Functional Mock-up Interface (FMI) standard.

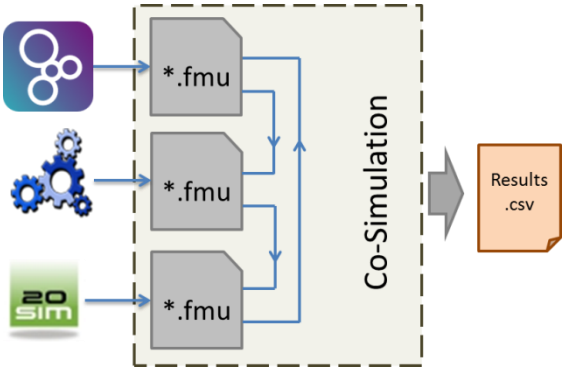

Figure 1: The single models can be exported as FMU from the tools and simulated together by the Co-Simulation engine.

Within INTO-CPS, the modelling tools Overture, OpenModelica and 20-sim are used. Since the Co-simulation engine is fully FMI compliant, any FMU that supports the FMI standard can be used as well. The signals that are exchanged between the Co-simulation are saved to file. The Co-simulation engine is Java based and can therefore be used on Windows, Linux and Mac platforms (32-bit and 64-bit).

In addition, a user interface was created that aims at easy setup of Co-simulation projects.

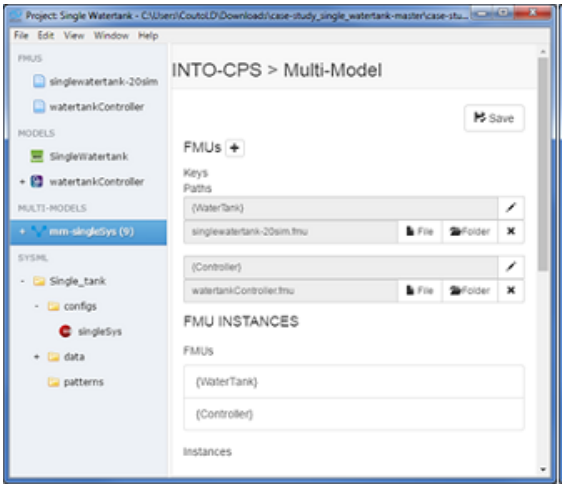

Figure 2: The user interface.

The user interface allows for easy configuration of the Co-simulation, selection of models, setting of parameters and view of results. The configuration, which describes the signals that are being exchanged between the different models (e.g. the FMUs), can be derived from the SysML model that is created by the Modelio tool.

The user interface also provides extensibility with other features (such as design space exploration, test automation or traceability) that will be presented in upcoming newsletters.

Spotlight on a Case study: Electric vehicle range calculation

The EU has pledged to reduce its energy consumption by 20 percent until 2020 (relative to the projected levels). Of the total energy consumption, transportation is responsible for 33.2 percent (in 2014)[1], which is predominantly provided by fossil fuels. While potentially more environmentally friendly alternatives, such as electric vehicles, are technically feasible and slowly entering the mass market, there are still obstacles in the way of widespread acceptance of these technologies.

One of the problems with electric cars is the limited range due to the lower energy density of batteries compared to fossil fuel. In addition, the network of charging points is still sparse, and recharging is rather time-consuming. Therefore, customers worry if they will reach their destination with their electric vehicle.

[1] http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy

To predict the range of electric vehicles correctly, TWT is developing a range prediction tool in its case study. The tool simulates the dynamics of the vehicle for a given route under constraints related to traffic and weather (important for the energy consumption of the A/C) (schematically shown in Figure 3). This tool optimises not only the duration of the trip, but also choses the route with the highest remaining battery charge.

Figure 3: Schematic concept of the automotive case study; a tool that optimises the route of an electric vehicle with respect to the remaining battery charge.

In the case study, the energy consumption of an electric car is calculated for a chosen route based on a physical model of the car and live data (weather, traffic) of the environment. Currently, the simulation models are transferred to the emerging INTO-CPS tools (see previous paragraph) to take advantage of their possibilities. In the future, incorporation into a hardware driving simulator is planned. This will provide feedback to the driver, depending on the remaining range.

Upcoming IFG webinar and workshop

To demonstrate the capabilities of the INTO-CPS tools, we are planning several webinars and workshops in 2016. After webinars in April and October (on automotive and building automation topics, respectively) and the first local face-to-face workshop in June in Linköping (Sweden), more events are coming up.

The **third webinar**, focused on railways applications, will take place on Thursday, **December 8th 2016** at 10 am (CET). There will be a presentation of the status of INTO-CPS and demonstrations of how to use the tools for different tasks in the development of railways signalling, as well as a Q&A session. More webinars will take place in 2017.

On **November 21st 2016**, there will be a **face-to-face workshop in Paris** (France). It will be held in conjunction with the INTO-CPS plenary meeting so IFG members from the region have the opportunity to talk to the INTO-CPS developers and experience the tools first-hand. So, we would be happy to welcome you in Paris on this date. The agenda is:

14:00 – 14:30	INTO-CPS Overview, status outlook
14:30 – 15:00	Tools (Overture, 20-Sim, OpenModelica, RT Tester, Modelio, COE)
15:00 – 15:15	Coffee break
15:15 – 16:30	Live demonstration & Hands-on testing
16:30 – 17:00	Questions & Answers

You can find more information on our website:

http://into-cps.au.dk/currently/events/show/artikel/seminar-for-the-into-cps-industry-follower-group-1/

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

November 8th: An INTO-CPS tutorial titled "Cyber-Physical Systems Engineering: Next generation Foundations, Methods and Tools" will be presented at the FM 2016 21st International Symposium on Formal Methods in Limmasol (Cyprus).

Recent publications

P.G. Larsen et al, *Integrated Tool Chain for Model-based Design of Cyber-Physical Systems: The INTO-CPS Project*, CPS Data workshop in connection with the CPS week.
http://dx.doi.org/10.1109/CPSData.2016.7496424

For more updates, visit our website:

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

visit our YouTube channel:

https://www.youtube.com/channel/UCHfzhFYht6sKiqarjqbmtaQ

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