MASCOT Messenger

Issue 1, June 2020

Editorial

This is the first issue of the MasCot Messenger, the newsletter of the ESI(TNO) and NWO-TTW MasCot programme.

This newsletter will bring you news and updates on the programme, and on its the four projects: DSE 2.0, SAM-FMS, Software Restructurings, and TiCToC. The intended audience of this newsletter are the projects members, programme committee members, user committee members of the four projects, and everyone interested in the programme.

Since the grant date of the projects in mid-December 2019, the MasCot core team, consisting of Wouter Leibbrandt (ESI), Mladen Skelin (NWO-TTW), Benny Akesson (ESI) and Harm Munk (ESI) has had virtual meetings with the leaders of the four projects. The purpose of those meetings was to get to know each other, to get informed about the content and goals of the projects, and to discuss the added benefit of being part of the MasCot programme. The MasCot core team has greatly appreciated these meetings and received positive feedback on programme membership. A short summary of the feedback can be found in this issue.

Also in this issue are descriptions of two of the four MasCot projects. The descriptions of the other two projects will be published in the second issue, scheduled to appear in early July 2020. Most of the projects will start hiring PhD students in the next few months. They will be asked to introduce themselves in this newsletter when they come aboard and keep each other and the MasCot community informed about the progress of their respective project work.

Enjoy reading this first issue. Suggestions and feedback are welcome at harm.munk@tno.nl

The MasCot Programme, more than four projects

In setting up the MasCot programme NWO-TTW and ESI have created an environment for projects focusing on the common topic of mastering complexity in the design of high-tech systems. For ESI and NWO it is a clear objective to run Mascot as a coherent programme and create connections wherever meaningful between the four projects. This way, led by the motto that whole is greater than the sum of its parts, we expect the outputs and outcomes of the programme to benefit immensely from synergy effects which in turn will have a positive effect on the increase of the programme's impact potential.

To that end, MasCot will organise several joint activities throughout the lifetime of the programme. The intention of the joint activities is to enable networking between the projects' members, have them exchange information and experience, and to challenge the PhDs to think about synergies between their work and about ways to combine their research.

One of these activities is the organisation of a yearly MasCot day, where we will invite not only the project members but also ESI's industrial partners, including those that do and those who do not host MasCot projects.

The MasCot core team will have frequent meetings with the project's members, preferably by visiting the respective institutes or at industry locations.

To inform the outside world of the programme and its progress, MasCot plans to be present and /or have workshops at conferences and exhibitions, such as the ESI symposium, ICTOpen, the HiPEAC conference and Computing Systems Week, and DATE.

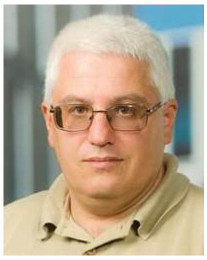
This newsletter, of course, is also intended to be a bonding mechanism between all the MasCot participants. As mentioned above, the first two issues will introduce the Mascot projects, while later on we aim to fill the newsletter regularly with news and developments from the programme and, once the projects are staffed, expect regular contributions from the PhD students and other Mascot participants reporting about the results of their research.

In the end, the stack of MasCot Messengers should convey the history and progress, but above all the contributions of the MasCot projects to the challenges posed by the design of complex systems. We are looking forward to you joining us and create a big success out of this exciting programme in which we together aim to master the complexity the industry is facing in designing highly digitalised systems and equipment.

Design Space Exploration 2.0: Towards Optimal Design of Complex, Distributed Cyber Physical Systems

Main applicant:
Dr. Andy Pimentel, University of Amsterdam

Co-applicant:
Dr. Todor Stefanov, Leiden University



Research Summary

Cyber-Physical Systems (CPS) comprise one of the largest information-technology sectors worldwide which is a driver for innovation in other crucial industrial sectors such as health industries, industrial automation and robotics, avionics and space. Nowadays, the embedded compute infrastructure of complex CPS is based on heterogeneous multi-core or many-core systems, which are distributed, and connected via complex networks. Manufacturing companies of *distributed Cyber-Physical Systems* (dCPS), such as ASML, Canon Professional Printers, and Philips, are facing serious challenges with respect to designing their next generation lithography scanner machines, industrial printers, and interventional X-ray machines, respectively.

Typically, these machines are very complex dCPS that integrate and interconnect a possibly large number of subsystems containing multiple dependent compute nodes (hardware and software components) that perform different tasks, e.g. data processing, control, monitoring, logging/reporting, etc., thereby realising a wide range of functionality and features.

Designers of such systems need quick answers to so-called "what-if" questions with respect to possible design decisions/choices and their consequences on system performance, cost, etc. This calls for efficient and scalable system level design space exploration (DSE) methods for dCPS that integrate appropriate application workload and system architectures models, simulation and optimisation techniques, as well as supporting tools to facilitate the exploration of a wide range of design decisions. However, such DSE technology for complex dCPS does currently not exist. Therefore, in this research proposal, we address the following main question: **How can we perform efficient and effective DSE for complex, distributed cyber-physical systems?**

More specifically, this project proposal concerns research on DSE techniques for complex dCPS in which exploration is performed in four dimensions: i) the *software workload* using workload models that can capture software process activities with a granularity that will allow the exploration of potential workload balancing techniques, degrees of parallelism, etc., ii) the *platform architecture* considering potential distributed architectures on which the workload can be mapped (e.g., deployment of 'fat' versus 'thin' compute nodes, exploitation of heterogeneous and possibly domain-specific system architectures, etc.), iii) the *mapping of software processes on platform resources*, and iv) the *exploration of different system configurations* to adapt the systems to specific workloads and platform architectures. Performing such DSE should lead to system optimisation in terms of objectives such as increased system performance and decreased system costs.

Utilisation Summary

This project aims at researching and developing novel DSE methods, techniques and tools that are applicable to a wide range of dCPS and application domains. Such DSE technology does not yet exist, thereby seriously hampering future product development by dCPS manufacturers like ASML, Canon Professional Printers, Philips, and others. Therefore, the research and development results of this project would significantly help the designers of next-generation dCPS and should lead to considerable improvements of industrial dCPS in terms of system performance and cost. To drive the research/development and to guarantee high industrial relevance and utilisation, the research/development will be performed in close collaboration with ASML, manufacturer of chip lithography machines which are very complex dCPS and can even be considered as a particular type of Systems-of-Systems (SoS). The techniques and methods that are going to be developed will be driven by an ASML use case, and the information collected from ASML's real systems will be used to assess the project results. The optimisation objectives that will be considered in this particular use case will be system performance, i.e., processed wafers per second, and the system costs, i.e., Non-Recurring Engineering (NRE) costs and area of the machine. This close industrial collaboration will stimulate knowledge uptake and utilisation by ASML.

Moreover, to stimulate further utilisation and knowledge transfer of the research/development results, a user committee will be installed, consisting of the project consortium partners (University of Amsterdam, Leiden University and ASML), as well as the users ESI (TNO), Philips Medical Systems, and Siemens. ESI is a Dutch institute for high-tech embedded systems design and engineering. ESI works at technology readiness levels (TRL) 4-7 and will be the main facilitator to bridge the gap between the delivered results in this project at TRL 3, demonstrated in the context of the ASML use case, by helping to transfer the knowledge and mature the results towards higher TRLs, thereby increasing the chance of successful utilisation by other companies in the ESI network. The other industrial users (Philips Medical Systems and Siemens) represent very different CPS application domains and should therefore help to generalise the developed DSE technology as well as increase the chances of industrial uptake and utilisation in a wide range of crucial industrial sectors.

Scheduling Adaptive Modular Flexible Manufacturing Systems (SAM-FMS)

Main applicant:
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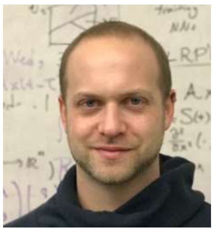
Co-applicant:
Dr. Neil Yorke-Smith, Delft University of Technology

Co-applicant:
Dr. Nils Jansen, Radboud University Nijmegen



Research Summary

Smart industry targets high quality, highly productive, customisable manufacturing. Optimising the productivity of Flexible Manufacturing Systems (FMS) is challenging. Today's FMS are Cyber-Physical Systems (CPS) where productivity depends on the interaction between physical processes, mechanical design and construction, and embedded software and control. Adaptivity and modularity in the FMS design increase flexibility and enable reuse. This improves market potential through product customisation and reduces development time and cost through reuse of components and technology. However, adaptivity and modularity complicate optimisation of productivity, because design choices and settings for one FMS configuration may not be optimal for another configuration. The SAM-FMS project addresses the challenge of ***co-designing the mechanical structure and the product flow scheduling of adaptive, modular FMS for optimal productivity***. Five specific scientific challenges are investigated:

(SC1) Modular scheduling and design – How to modularise and distribute FMS scheduling?

(SC2) Real-time scheduling and design – How to ensure real-time performance of FMS schedulers?

(SC3) Robust scheduling and design – How to develop schedule(r)s that are robust against variations in operation, configuration, or usage?

(SC4) Parameterisation – How to relate and co-optimise structural FMS parameters (such as transport speeds and buffer capacities) and scheduling parameters?

(SC5) Schedule(r) learning – How to learn and evolve schedules and schedulers from operational FMS and schedule data? The SAM-FMS project will contribute to the development of high-performance, customisable, and robust FMS. The obtained scientific results will be validated in industrial practice.

Utilisation Summary

The SAM-FMS research will be performed in close collaboration with industrial partners Canon Professional Printers, ASML, and Vanderlande and research organisation ESI (TNO). ESI has a strong valorisation track record. We adopt the ***industry-as-lab model***, where an industrial driver case forms the basis for the scientific research. The model ensures that we solve realistic and relevant problems. We then generalise specific solutions to more general principles that also work for other application domains and we validate the results in industrial practice. In SAM-FMS, Canon production printers, like the VarioPrint i300 (https://vimeo.com/119897713), form the driver. Results will be validated with Canon, for production printing, ASML, for chip manufacturing, and Vanderlande, for warehousing and luggage handling. The collaborations will be realised by weekly presence at Canon, by Canon hosting a Professional Doctorate in Engineering (PDEng) student, and through joint Master student projects with all three industrial partners.

SAM-FMS will deliver (1) **customisable product flow schedulers** for modular, adaptive FMS that ensure high productivity and robust online operation within strict timing budgets; (2) **methods to co-design** the mechanical structure of an FMS and its product scheduling. The industry-as-lab model ensures transfer of mature results to the industrial partners already within the scope of the project. Results will be made available to the wider industrial and academic community through the eXplore CPS (http://xcps.info) FMS emulator, in the form of publicly accessible xCPS models, scheduling benchmarks, and scheduling and codesign tooling. Results will be presented at industry-relevant events like the ESI symposium and ICT.Open.

We will integrate results in our university curricula and offer training to interested industrial parties. Scheduler technology lies at the heart of manufacturing, determining how goods are produced and at what quality, speed, and costs. Thus, the scheduling technology and co-design methods developed by SAM-FMS will be of great added value to many branches of manufacturing industry.