PhD Position

IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

PhD Subject

Automated reconfiguration by AI-augmented model transformation

Supervisors

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Keywords

- Model Transformation; Model Driven Engineering
- Constraint Programming; Optimization
- Reconfiguration

Context

Modern software and cyber-physical systems need reconfiguration. For example, Reconfigurable Manufacturing Systems (RMS – [1]) are a very active field of research. When switching from one configuration to another, a RMS needs to reconfigure both hardware and software components. Cloud systems are another example of a reconfigurable system where complex decisions are required to ensure proper software (re)deployment.

Model-driven engineering (MDE) provides tools to create and manipulate abstractions of complex systems. It has proven to be useful in the software industry for tasks like model-driven reconfiguration (MDR). In MDR, models are used to represent systems and reconfiguration objectives, and model transformations are exploited for the reconfiguration process and connection of the model with the actual system. While promising, the industrial acceptance of MDR in application domains like RMS is hampered by the difficulty for domain experts to manually develop correct and efficient transformation programs.

The objective of this thesis is to simplify the development of model-driven reconfigurations by relying on AI techniques. We aim at enabling the definition and analysis of reconfiguration transformations directly by domain experts. This would strongly increase the applicability of Naomod tools and techniques to these domains.

Scientific goals

RMSs have received a large interest in the academic field over the years with complementary perspectives: RMS design enhancing reconfigurability possibilities [2], new technologies for RMS [3], or formal definition of the configurations [4]. This PhD subject focuses on the reconfiguration phase.

We want to simplify the definition of optimal reconfigurations by providing an innovative way to define transformations that include both 1) deterministic transformation rules with 2) solutions to optimization problems by AIs, with particular attention to methods related to constraint programming.

ATLc [5] is a declarative rule based model transformation language that allows users to generate models with constrained properties that can be computed by constraints solvers. ATLc already supports several constraints solvers such as Choco or Cassowary. The thesis aims at extending ATLc to support constraints on the structure of the generated model (e.g. adding missing elements) which is not currently supported by ATLc, and required by reconfiguration tasks. This will require an extension of the language syntax and computational model. We aim at a transformation language that can integrate with the computational model of different AI tools, including different constraint programming techniques, simulation engines, and smart Life Cycle Analysis tools.

Environment

The employer is IMT Atlantique. The student will be a member of the NaoMod and TASC research groups of the LS2N lab and will be located at the IMT Atlantique in Nantes.

The PhD contract is fully funded for 3 years and is expected to start in october 2022.

Requirements

The candidate must hold (or is about to obtain) a Master Degree in Computer Science with strong skills in Software Engineering and/or Constraint Programming.

Prior experience with these technologies is appreciated:

- Java, Xtend
- EMF, ATL
- Choco

The candidate should be fluent in English (working and publishing main language).

How to apply

Applicants should send us their application **before June 26th** with::

- A full curriculum vitae, including a summary of previous research experience
- A transcript of grades
- research/development project (master's degree project, subject of the internship, …)
- A motivation letter
- 2/3 support letters of persons that have worked with them

To apply and for information please send an email with "**[AI-MT PhD]**" in the subject to

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References

[1] Y. Koren et M. Shpitalni, « Design of reconfigurable manufacturing systems », J. Manuf. Syst., vol. 29, no 4, p. 130-141, oct. 2010, doi: 10.1016/j.jmsy.2011.01.001.

[2] A.-L. Andersen, T. D. Brunoe, K. Nielsen, et C. Rösiö, « Towards a generic design method for reconfigurable manufacturing systems: Analysis and synthesis of current design methods and evaluation of supportive tools », J. Manuf. Syst., vol. 42, p. 179-195, janv. 2017, doi: 10.1016/j.jmsy.2016.11.006.

[3] N. Kousi, S. Koukas, G. Michalos, et S. Makris, « Scheduling of smart intra – factory material supply operations using mobile robots », Int. J. Prod. Res., vol. 57, no 3, p. 801-814, févr. 2019, doi: 10.1080/00207543.2018.1483587.

[4] E. Capawa Fotsoh, N. Mebarki, P. Castagna, P. Berruet, et F. Gamboa, « Towards a Reference Model for Configuration of Reconfigurable Manufacturing System (RMS) », in Advances in Production Management Systems. The Path to Digital Transformation and Innovation of Production Management Systems, Cham, 2020, p. 391-398, doi: 10.1007/978-3-030-57993-7_44.
[5] Le Calvar, T., Chhel, F., Jouault, F. et al. Coupling solvers with model transformations to generate explorable model sets. Softw Syst Model 20, 1633–1652 (2021). https://doi.org/10.1007/s10270-021-00867-0