Internship proposal

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Real-time analysis and verification of ROS2 robotic applications

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1 Context and Motivation

ROS is the most popular framework for the development, prototyping and deployment of robotic applications, with thousands of off-the-shelf components ready to use across multiple platforms. However, a major weakness of ROS is the absence of real-time guarantees, making it difficult to prove (or at least guarantee with some confidence) the safety of ROS-based robotic applications vis-à-vis timed properties, especially in the presence of data shared among ROS services. Since 2015, work has been done on a more real-time version of ROS, called ROS2 (a first release was produced in 2017). This new version offers more deterministic mechanisms in terms of communication and execution. In particular, the addition of an execution management mechanism (called Executor) allows to define more clearly the behavior of the application threads. As for communication, it has gained in determinism thanks to the use of the DDS standard. Work in progress [1, 2] is investigating these different aspects and should eventually allow to develop reliable real-time robotic applications using ROS2.

The objective of this Masters internship is to get familiar with the notion of Executor of ROS2 as well as with the DDS standard in order to enable rigorous analysis of timed behaviours. This study is a first step to approach the verification of ROS2 applications. Several elements will be explored during this master's internship : - bibliographical study on DDS and on ROS2 Executor : to make a bibligraphic study in order to identify precisely the current solutions made at the level of services with data sharing. A particular focus will be put on the modeling or the methods allowing to model and to validate these mechanisms. - Modeling and verification of real-time behaviors in a ROS2 application : the objective is to formally model the behavior of an application developed in ROS2 taking into account the DDS and/or Executors. The methods and tools for formal modeling will be chosen at the beginning of this task, with a focus on mixed methods combining transition-system-based verification and schedulability analysis in the style of [3] - Setting up a ROS2 experimentation platform : the goal here will be to deploy ROS2 on a physical hardware. Several alternatives are possible depending on the hardware target, either on a CPU with a Linux support or on a microcontroler with a dedicated RTOS. This platform will be used to evaluate the temporal performances of these different supports.

2 The Candidate

Necessary requirements : The desired candidate is a Masters student in computer science or a closely related field (preferably in the last year, equivalent to second year of Masters). Motivation and committment to learn and explore challenging research problems are a must.

Highly desirable requirements are solid background and skills in : - formal methods (modeling, verification) - real-time systems (scheduling, data sharing) - programming

Desirable requirements : Knowledge of ROS.

3 Location

The intern will be based in Laboratoire des Sciences du Numérique de Nantes (LS2N) in Nantes and will be visiting Institut de Recherche en Informatique Fondamentale (IRIF). In exceptional situations, hosting the intern at IRIF instead of LS2N can be arranged.

4 Application

To apply for this position, please send an email with your CV (mandatory) and motivation letter (optional but strongly recommended) to the internship advisors at pierre-emmanuel.hladik@ls2n.fr and foughali@irif.fr.

5 Bibliography

[1] Varillon, Benoit and Chaudron, Jean-Baptiste and Doose, David and Lesire, Charles Corail, ROS 2 temps réel. Corail, ROS2 temps réel. In : ROSConFr 21, 22 June 2021 - 23 June 2021 [pdf]

[2] Casini, Daniel ; Blaß, Tobias ; Lütkebohle, Ingo ; Brandenburg, Björn B. Response-Time Analysis of ROS 2 Processing Chains Under Reservation-Based Scheduling. In Proc. of 31st Euromicro Conference on Real-Time Systems (ECRTS 2019) — 2019 [pdf]

[3] Foughali, Mohammed ; Hladik, Pierre-Emmanuel. Bridging the gap between formal verification and schedulability analysis. Journal of systems architecture. 2020. [pdf]