## Towards hierarchical and distributed run-time monitors from high-level query languages

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**Context.** A *cyber-physical system (CPS)* consists of computation, communication and control components tightly combined with physical processes of different nature, e.g., mechanical, electrical, and chemical [1]. Compared to traditional embedded systems, key characteristics of a CPS include a (1) *massive number of heterogeneous nodes* ranging from cheap, low-energy smart devices to mobile phones to high-end cloud-based servers, (2) *adaptability to conditions* that differ significantly from the ones they were designed for (new requirements, new services, new platforms, failures) in dynamic environments, while (3) *delivering critical services in a trustworthy way*. Such systems include autonomous and connected cars, smart healthcare devices, smart factories, smart homes or smart cities.

**Problem statement.** Due to their dynamic nature, the assurance of smart and trusted CPS typically relies on run-time verification, which aims to check if their execution at run-time meets its requirements [2]. For instance, the data provided by force torque sensors and tactile sensors of an automated robot arm can be evaluated to decide if the arm is in a dangerous situation. High-level property languages are increasingly used for specifying complex structural conditions of the system. These properties are either evaluated over run-time models (which are directly connected to the system itself) or they serve as an input for synthesizing run-time monitors for a heterogeneous platform. However, due to resource constraints of these devices (e.g. CPU, memory, energy) and the continuously evolving platform and services, the deployment of hierarchical monitors to such a target platform is a very challenging task.

**Objectives.** In this line of research, we aim to continuously evaluate properties captured in high-level query languages over run-time models by deploying them over a heterogeneous platform for run-time verification purposes. While efficient incremental and search plan-based query optimization techniques have been developed in model-driven engineering [3] as well as for graph databases [4], their application in an environment with strict resource constraints and soft real-time requirements is a major challenge. As a first step, we illustrate these challenges in the context of the MoDeS3 demonstrator [5] developed for the Eclipse IoT Challenge 2016.

## References

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