QAIS

Quantitative analysis of interacting systems: foundations and algorithms

(A PhD proposal)

1 Context

The QAIS project (PTDC/EIA-CCO/122240/2010), recently funded by the Portuguese Science Foundation is placed in an emerging research area that of quantitative methods for analysis of complex, reactive systems.

We are looking for a bright, enthusiastic student, holding a master (or equivalent) degree in Computer Science or Mathematics to work on the QAIS project, details on the research topic follow below.

We are offering a 9 months fully funded scholarship with possibility of extension, starting in December 2012. The candidate is supposed to use this period to develop initial results, and enhance his/her curriculum with recognised publications, in order to prepare a successful application to a FCT PhD grant in the 2013 Call.

The student would be jointly supervised by Luis Soares Barbosa (UMinho & INESC TEC) and Alexandra Silva (Radboud University Nijmegen & INESC TEC). The QAIS project has an international character with renowned consultants, including Prof. Prakash Panangaden (McGill University, Canada), and Dr. Ana Sokolova (University of Salzburg) and Dr. Filippo Bonchi (ENS Lyon, France).

2 Description of the proposed research

In order to study services from a quantitative perspective, there is a need to shift from classical models of computation, such as labeled transition systems, to more elaborate ones, such as weighted or probabilistic automata, where quantities can be modelled. Many probabilistic systems have been studied in the literature. One of the goals of QAIS is to uniformly define notions of metrics for all the probabilistic systems modelled coalgebraically (e.g. in the work of Bartels, Sokolova, and de Vink). In order to do that, we first plan to lift all the functors considered from the category of sets to metric spaces. Van Breugel and Worrell introduced a notion of metric for reactive probabilistic systems, which strongly relies on the existence of a final coalgebra. In order to generalize it to other functors, another subgoal is to study conditions under which the existence of a final coalgebra is guaranteed for the involved functors.

Metrics allow for the definition of approximate, ϵ-behavior equivalences (bisimilations), where systems that behave almost the same (converge to the same behavior when ϵ tends to 0) are identified. Several such has been already studied in the literature. Within the QAIS project, we aim to get an abstract notion of a metric bisimulation that corresponds to the post-fixed point of a certain operator.

Language equivalence of finite DA and bisimilarity of finite LTS can be be effectively computed via the Myhill-Nerode algorithm and the partition refinement algorithm. These two are instances of a well-known abstract coalgebraic algorithm that has inspired the design of new algorithms for more peculiar equivalences as well as, recently, for approximating behavior metrics. Within

the QAIS project, we would like to provide and abstract algorithm that would cover the computation of all uniformly defined behavior metrics. Furthermore, we plan to design algorithms for computing the metric quotient of a system, i.e., a new system that is metric equivalent to the original one and minimal. Another algorithmic problem within our goals is related to on-the-fly techniques for computing behavioral metrics. Such a method could be effective for automatically over-approximating the distances of systems with continuous state space.

Last, but not least, a goal of QAIS is to implement a prototype tool encoding all the above mentioned algorithms. The prototype tool should be implemented a functional language such as Haskell and linked to the coinductive theorem prover CIRC.