PROFUNDIS: Second Year Report
Deliverable – Workpackage 2: Specifications

Contents

1 Summary

This deliverable describes the scientific contributions of the second year for WP2 and includes the contributed papers as appendices.

The objectives of WP2 for the second year were expressiveness and decidability results for several logics for mobile processes and semi-structured data, refined proposals of a base logic, and first prototypes of verification tools and worked out case studies.

In summary, the scientific contributions are the following:

- Expressiveness results for a spatial logic for systems specified in the synchronous Pi-calculus with recursion. Decidability of model-checking for the above logic.
- Expressiveness and minimality results for several spatial logics. Spatial adjunct elimination without loss of expressive power.
- Complexity results related to XML schema, in a tree logic that is a form of spatial logic. Decidability of a language for semistructured data.
- A prototype tool for model-checking distributed systems modelled in the pi-calculus. Development of some case studies.

2 Contributions

We present the contributions per task of the workpackage.

Task 2.1: Logics for systems with spatial and temporal structure

A spatial logic for systems specified in the synchronous Pi-calculus with recursion was investigated, based on a small set of behavioral and spatial observations [Cai03]. A sequent calculus based proof system for a related spatial logic, refining previous work [CC03, CC04], was also developed.

Expressiveness results for this logic were studied. It is also shown that model-checking in this logic is decidable for a useful class of processes that includes the finite-control fragment of the Pi-calculus. Results about model-checking mobile ambients were also established [CDG$^+$03].

Task 2.2: Expressiveness

Expressiveness and minimality results have been obtained for spatial logics, showing that they can be expressed within a core, calculus-independent, spatial logic [HLS03]. In particular, it has been established that these spatial logics can express potentiality of interaction as they appear in the Hennessy-Milner logic. Minimality has also been addressed for the static Ambient Logic with operator of name revelation and fresh name quantification, in this context it was proved that the spatial adjunct operator can be eliminated in behalf of the remaining connectives without losing expressive power [Loz03].

Tree automata were applied to obtain several complexity results related to XML schema, in a tree logic that can be seen as a form of spatial logic [DL03]. This approach was also applied to derive the decidability of the quantifier-free, static fragment of ambient logic, with composition adjunct and iteration, which corresponds to a kind of regular expression language for semistructured data [DL04].

Task 2.3: Tools and case studies

A prototype version of a tool for model-checking distributed systems modelled in the pi-calculus against a version of a spatial logic was implemented, and will be made available on the web, and integrated with the PROFUNDIS Verification Environment [VC03]. Some case studies have been already tested and implemented using this tool. A sound and complete sequent calculus-based proof system for a core spatial logic was developed, and the corresponding decision procedure for validity of formulas has led to a prototype implementation, to be further developed in the project. Some case studies of concurrent systems related to global computing (e.g., peer-to-peer algorithms) were already used to test the usefulness of the logics developed in PROFUNDIS.

3 Publication List

[Cai03] L. Caires. Behavioral and spatial properties in a logic for the pi-calculus. In Igor Walukiwicz, editor, *Proc. of Foundations of Software Science and Computation Structures'2004*, Lecture Notes in Computer Science. Springer Verlag, 2003.

[CC03] L. Caires and L. Cardelli. A Spatial Logic for Concurrency (Part I). *Information and Computation*, 186(2):194–235, 2003.

[CC04] L. Caires and L. Cardelli. A Spatial Logic for Concurrency (Part II). *to appear in Theoretical Computer Science*, 2004.

[CDG+03] Witold Charatonik, Silvano Dal Zilio, Andrew D. Gordon, Supratik Mukhopadhyay, and Jean-Marc Talbot. Model checking mobile ambients. *Theoretical Computer Science*, 308(1):277–331, November 2003.

[DL03] Silvano Dal Zilio and Denis Lugiez. XML schema, tree logic and sheaves automata. In *RTA 2003 – 14th International Conference on Rewriting Techniques and Applications*, volume 2706 of *Lecture Notes in Computer Science*, pages 246–263. Springer, June 2003.

[DL04] Silvano Dal Zilio and Denis Lugiez. A logic you can count on. In *POPL 2004 – 31st Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages*, 2004.

[HLS03] D. Hirschkoff, E. Lozes, and D. Sangiorgi. Minimality results for the spatial logics. In *Proc. of FSTTCS'2003*, LNCS. Springer Verlag, 2003.

[Loz03] E. Lozes. Adjunct elimination in the static Ambient Logic. In *Proc. of EXPRESS'2003*, 2003. to appear in ENTCS, Elsevier.

[VC03] H. Vieira and L. Caires. Spatial Logic Model Checker User's Manual. Technical report, Departamento de Informatica, FCT/UNL, 2003.