Scientific Report

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I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

My research during the ERCIM fellowship divides into two related parts. The first part concerns decidability two-variable logics. The second part consists of descriptive complexity of distributed computing.

Two-variable logic is a currently a very active mainstream research topic in logic. Concerning two-variable logics, I produced three completely new research papers on the topic, and finalized a fourth one.

In the article *One-dimensional fragment of first-order logic*, which is joint work with Professor Lauri Hella, we defined and investigated a generalization of two-variable logic. This generalization extends the scope of two-variable logic to situations where relations can have an arbitrary arity. Two-variable logic as such is *often not useful* for example in database theory *due to the arity limitations*. In the new generalized framework such limitations do not hold. Furthermore, the new generalized logic has the same complexity as ordinary two-variable logic (NEXPTIME). This is proved in my joint article *Complexity and expressivity of uniform one-dimensional fragment* with Emanuel Kieroński.

Concerning two-variable logics, I also produced an article titled *A double team semantics for generalized quantifiers*. This article investigates two-variable logics in the framework of team semantics, which is a new generalized semantics (defined in the 90s) that involves a compositional representation of game-theoretically motivated concepts. This article is currently under review. I also worked on the finalization process of the joint article *Complexity of two-variable dependence logic and IF-logic* with Juha Kontinen and Jonni Virtema, and initiated a related continuation paper (which will be submitted before the end of the ERCIM fellowship).

I also worked on systems closely related to two-variable logics. The article *Second-order propositional modal logic and monadic alternation hierarchies* discusses alternation hierarchies of second-order logic in the modal context. The article *Some Turing-complete extensions of first-order logic* defines a canonical extension of first-order logic that is Turing complete in expressivity. An investigation of the decidable fragments of this logic will be carried out in the future.

Concerning descriptive complexity theory of distributed computing, I produced the article *Infinite networks, halting and local algorithms*. The article shows that in the widely studied *port-numbering model*, all universally halting algorithms are constant-time algorithms, as long as infinite networks are allowed. I also showed that in the finite, even the weakest known restrictions of the port-numbering model contain algorithms that are universally halting but not constant-time.

I also presented my article *Modal logic and distributed message passing automata* in the conference CSL 2013, and worked on the finalization process of the joint article W*eak models of distributed computing, with connections to modal logic* with Lauri Hella and six other co-authors.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

1. Emanuel Kieroński and Antti Kuusisto. Complexity and expressivity of uniform one-dimensional fragment with equality. Accepted to MFCS 2014.

    This paper proves that the complexity uniform one-dimensional fragment with equality is complete for NEXPTIME.

2. Lauri Hella and Antti Kuusisto. One-dimensional fragment of first-order logic. Accepted to AiML 2014.

    This paper introduces the uniform one-dimensional fragment of first-order logic. This fragment generalizes the two-variable fragment of first-order logic to contexts where relations of arbitrary arities can be meaningfully considered. The fragment is shown decidable and its expressivity is compared with other known decidable fragments of first-order logic.

3. Antti Kuusisto. Some Turing-complete extensions of first-order logic. Accepted to GandALF 2014.

    This paper defines a canonical extension of first-order logic and shows that it is Turing complete in expressivity.

4. Antti Kuusisto. Infinite networks, halting and local algorithms. Accepted to GandALF 2014.

    This article shows that in the port-numbering model of distributed computing, all universally halting algorithms are constant time algorithms when infinite networks are allowed.

5. Juha Kontinen, Antti Kuusisto, Peter Lohmann and Jonni Virtema. Complexity of two-variable dependence logic and IF-logic. Accepted to Information and Computation.

    This article shows that while the two-variable fragment of dependence logic is NEXPTIME-complete, the two-variable fragment of IF-logic is undecidable.

6. Antti Kuusisto. Second-order propositional modal logic and monadic alternation hierarchies. Provisionally accepted; on second round of review concerning *minor* modifications.

    This paper investigates second-order quantification in modal logic. The alternation hierarchy of SOPML is shown infinite.

7. Antti Kuusisto. A double team semantics for generalized quantifiers. Pending;

under review.

This article defines a canonical double team semantics for generalized quantifiers. The article also defines the notion of a generalized atom and a minor quantifier. The paper investigates complexity two-variable logics in the novel framework.

Disclaimer: The above list of articles contains only work relevant to the authors ERCIM fellowship. A small number of other articles were also accepted /finalized during the fellowship. These were either fully prepared outside the fellowship period, or, alternatively, not connected to the research plan concerning the fellowship period (being instead related to research projects before the fellowship period).

Journal versions of articles 1,2,3 and 4 will be credited to the fellowship period. The preparation process is in progress.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

22nd EACSL Conference on Computer Science Logic (CSL 2013), 2-5 September 2013, Torino, Italy.

Academy Colloquium on Dependence Logic, 4-5 March, 2014, Amsterdam, The Netherlands.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

My first REP was to the Institute of Informatics, University of Warsaw, Poland, 9-13 June, 2014. The local contact was Mikołaj Bojańczyk. I learned useful information about automata that share similarities to the message passing automata studied in my project on descriptive complexity of distributed computing. I also got present my work on generalizations of two-variable logic.

My second REP was to INRIA/IRISA, Université de Rennes 1, France, from 30 June to 4 July, 2014. My local contact was Guillaume Aucher. I learned useful information about similarities between issues in multiagent systems and automata in my project on descriptive complexity of distributed computing. I also got to present my work on descriptive complexity of distributed computing, and initiated a paper on team semantics.