



COMPUTING SCIENCE

1 August, 2014

Dear Dean Kratochvíl,

It is my pleasure to provide a report on the doctoral thesis of Mr. Jakub Bulin. The thesis consists of three papers unified by the general problem they consider and the methods used. The thesis contains three main new results, each of which highly nontrivial and significantly advances our knowledge in universal algebra and the constraint satisfaction problem (CSP). To obtain the main results Jakub uses several very interesting proof techniques that are also a substantial contribution of his thesis.

A major research direction in universal algebra and computer science is the complexity of the CSP. The Dichotomy Conjecture proposed by Tomas Feder and Moshe Vardi states that every CSP is either solvable in polynomial time or is NP-complete. Later, close connections between the complexity of the CSP and certain properties of universal algebras have been demonstrated that have greatly assisted in the CSP research since then. Although the Dichotomy Conjecture remains unresolved it has been refined further by asking what the complexity classes are, in which the CSP can be complete. Among such classes are PTIME, LOGSPACE and nondeterministic LOGSPACE, several counting classes. Not surprisingly, all of these classes have their (conjectured) analogues in different types of universal algebras, and the hope is to prove the links between them.

It is known from the Feder and Vardi paper that the Dichotomy Conjecture for the general CSP is equivalent to the one for a very special class of digraphs. In the first part of his thesis Mr. Bulin significantly improved this result showing that a similar result is true not only the border between polynomial time tractability and intractability, but also for almost all natural complexity classes and properties of algebras. To achieve this result Mr. Bulin had to advance the technique based on using oriented paths and trees, and come up with intricate constructions of digraphs corresponding to relational structures.

The third part of the thesis also revolves around oriented trees. Mr. Bulin proved the Dichotomy Conjecture for a certain class of oriented trees that he (somewhat unexcitingly) called special trees. This result is achieved by showing that such trees, unless they give rise to an NP-complete CSP, have bounded width, and therefore can be solved by the standard propagation algorithm.

One of the most prominent recent developments in universal algebra is the theory of absorption suggested by L.Barto and M.Kozik. This theory rises a number of algorithmic questions related to absorption, such as if absorption is decidable, and if it

BURNABY
9971 Applied Sciences Building
8888 University Drive
Burnaby BC V5A 1S6
Canada

SURREY
250-13450 102 Avenue
Surrey, BC V3T 0A3
Canada

Tel: 778-782-4277
Fax: 778-782-3045
Web: www.cs.sfu.ca

is, how difficult it is to decide absorption. The second part of Mr. Bulin's thesis addresses and (positively) resolves this question in the important particular case of relational structures of bounded width.

Two of the three parts of the thesis has gone through a rigorous review process and have been accepted to reputable international journals, which also witnesses high quality of Jakub's research. The results obtained by Mr. Bulin clearly demonstrate that he is capable of producing highly creative, elegant, and at times, technically challenging work. He made substantial contributions into both universal algebra and the CSP and deserves the degree.

Sincerely yours,



Andrei Bulatov
Professor
School of Computing Science,
Simon Fraser University
Burnaby, B.C. V5A 1S6
tel: (778) 782-6913,
fax: (778) 782-3045,
email: abulatov@sfu.ca