

REQUEST FOR SABBATICAL LEAVE

Name: K. Kalorkoti.

Duration of leave requested and preferred period: whole year, academic year 2019–20 preferred.

Research to be carried out: The Lukasiewicz μ -calculus was introduced by Mio and Simpson (published 2017) and has attracted serious attention from the research community. Their best bound for solving terms was double exponential time and relied on the decision procedure for linear arithmetic of Boigelot et al. I worked on the problem over a long period and developed a single exponential time algorithm which was published in *Theoretical Computer Science* 712 (2018). The method is self contained except for the use of fraction free Gaussian elimination and introduces new techniques in the area of model checking (to quote from a referee: “Moreover, the techniques introduced by this author may be of interest in the area of model checking of distributive systems, which is quite an active topic”). In this paper I also showed that the size of solutions is polynomially bounded in terms of the size of the input term. However it is not known if the problem is in NP, in contrast to the modal μ -calculus introduced by Kozen. A more ambitious aim would be to show that it is either in $NP \cap co-NP$ (which is the case for the modal μ -calculus) or NP-complete. Another interesting question is the status of terms with just one variable, it seems likely that they should be easier to solve. In the paper cited I also gave a heuristic that is often very successful and speeds the solution process significantly for general terms. In my proposed research I will address the NP membership question, the solution of single variable terms as well as aim to find easily verifiable technical conditions under which the heuristic is guaranteed to work. On a more general point, it would be of interest to look at methods of solution with some restrictions with the aim of establishing either resource costs or impossibility results. This last aspect relates to the study of the heuristic mentioned. Most of this work is likely to require the development of more new methods.

On a different thread I have published two papers with work related to Gröbner-Shirshov bases (*Communications in Algebra* 2011 and 2017); these bases have been studied in many publications over recent years in particular by Leonid Bokut’ and co-workers. These bases are normally infinite and, beyond their existence (which is guaranteed), they can be very hard to work with. An aspect that I have started to work on already is to find conditions for invariants satisfied by a basis that can be used in questions of embeddings, in particular for monoids and groups. The immediate motivation for this is the study of the word problem for groups all of

whose generators are involutions, this is motivated by a question raised from groups of invariants for dynamical systems introduced by Vassily Manturov.

Reasons for supporting the proposal: At my last but one PDR review with Colin Stirling we discussed a sabbatical as a way to progress my research activity. We agreed that it would be a good idea to apply for a sabbatical year, when I had such a year previously it proved very productive. For various reasons I decided to wait till this academic year to apply. The main reason I need a sabbatical is that the research outlined above (for the Łukasiewicz μ -calculus) requires a long period of uninterrupted work. One reason the work on the single exponential algorithm took quite a long time is because I had also to focus on other time consuming duties.

Practical issues arising: Currently I teach the ADS thread of Inf2B, the UG4 course on Computer Algebra and I am the School Academic Misconduct Officer. I have made very extensive revisions of the notes and tutorial sheets for Inf2B and have also produced three separate practicals with supporting materials all of which can be taken over by another member of staff with ease. The Computer Algebra course would need to be suspended, it is in any case specialist and attracts a small number of students. The position of SAMO is one that requires a great deal of care and I would of course be happy to discuss matters with a successor.

I am supervising the project of an MInf4 student. The MInf5 phase requires familiarity with aspects of Gaelic plans (required from public bodies in Scotland) and it might be difficult for another member of staff to act as supervisor. In such a case, I would be happy to continue supervising this student during a sabbatical and take part in the associated activities for this project.