

# Mac Robertson Travel Scholarship Report

Matthew McIlree

June 19, 2025

## About Me

My name is Matthew McIlree and I am from Scotland. I am currently a 3rd year PhD student in the Formal Analysis, Theory and Algorithms (FATA) research group within the school of Computing Science at the University of Glasgow. I am supervised by Dr. Ciaran McCreesh, and the focus of my research is developing *proof logging* techniques for *constraint programming* (CP) solvers.

A CP solver is a complex piece of software that takes a mathematical model as input, and determines the exact (optimal) solutions if they exist. In critical applications, it can be vital to trust that this is achieved without errors, and proof logging is a technique to increase reliability by having the solver produce a mathematical certificate of correctness in a machine-readable format, which can then be independently checked by an external verifier program.

I was awarded a Mac Robertson travel scholarship with a value of £5000 to visit the Optimisation Research group lead by Prof. Peter Stuckey at Monash University, Melbourne, Australia, from 1st April to 31st May 2025.



## Why Did I Apply for a Travel Scholarship?

In addition to being a centre of expertise in constraint programming and discrete optimisation, Peter Stuckey's research group at Monash is where the widely-used *MiniZinc* modelling language is primarily developed [4]. There is a wealth of knowledge among the group members about the relationship between high-level problem descriptions and low-level solver details; constraint propagation algorithms; interfacing different technologies; and potential industrial applications.

I felt that seeking a new collaboration with this group through an in-person research visit would be an excellent opportunity for my personal research development, as well as for the wider project goal of improving certification for CP solvers. Given the large geographical and time-zone distance between Glasgow and Melbourne, it would have been logistically challenging to pursue this without the support of the scholarship.

## Details of the Visit

Prior to my visit, I discussed with Peter Stuckey several possible ideas for an eight-week mini-research project. We decided it would be interesting to try adding proof logging to the newest CP solver being developed at Monash. This solver, called “Huub” [2] is a *Lazy Clause Generation* solver, which means it makes use of a powerful SAT solver as a lower-level reasoning engine.

Throughout the eight weeks we discussed and implemented prototype solutions for several technical challenges, including:

- How to interface with the SAT solver to ensure the necessary proof information is logged during the solving process.
- How to make proof logging more efficient and easier to implement by considering “proof hints” and “annotated assertions” as new features of the *VeriPB* proof system [1].
- What an overall framework for mixing different *justification mechanisms* might look like.



Since *Huub* is being developed in the *Rust* programming language [3], which I had never previously worked with, I took the opportunity to learn this language from scratch. I received invaluable mentorship from Dr. Jip Dekker, the primary developer of *Huub*, including pair-programming sessions, and in-depth technical discussions. I attended the weekly *Huub* development meetings with Jip, Peter and the other solver developers, as well as the weekly optimisation group meetings.

## Impact of the Travel Scholarship

By virtue of being physically present in Melbourne, I had the opportunity to give several in-person research presentations during my visit, including a 30-minute talk introducing myself and my research to the Monash group; and a 50-minute seminar for the OPTIMA Research Institute, which is a collaboration between Monash University, the University of Melbourne, and ten industrial partners. I believe I managed to effectively convey the philosophy behind proof logging, and get more people interested in the idea.

By the end of the visit, we had a working prototype of a method for *Huub* to produce certificates of correctness. We relied on unjustified axioms for most constraint propagation inferences, but successfully demonstrated the new syntax and framework that we had developed. The next step will be to expand the axioms into a full proof with an external “justifier” program, which I began to work on in the final weeks of the visit. We agreed to continue to collaborate remotely on the project long term, and work towards a multi-author publication to showcase some of the ideas and tools developed.

So overall the scholarship has allowed me to acquire new technical skills, gain new long term collaborators, and advanced the state-of-the-art and visibility of proof logging for constraint programming solvers.



View from the "Pinnacle" at Hall's Gap, Grampians National Park.



Me at the "Twelve Apostles" sea stacks.



A kangaroo.

Picture from my (Great Ocean) road trip.

## Acknowledgements

In addition to Peter Stuckey and Jip Dekker, who were my primary collaborators at Monash, I benefitted from several interesting discussions with Dr. Allen Zhong and fellow visitor Dr. Lucas Kletzander. I was also made to feel very welcome by the wider research group and particularly the junior members, who were kind enough to invite me to dinner in Oakleigh and try the famous Greek cuisine; to their weekly "Burger Friday" lunch; and to a pizza and board games event as a send-off on my last day.

Special thanks to Lucas for bringing me on a weekend road trip to see part of the "Great Ocean Road" and take in some of the amazing Australian scenery and wildlife. See above for some photos.

## References

- [1] Bart Bogaerts, Stephan Gocht, Ciaran McCreesh, and Jakob Nordström. Certified Dominance and Symmetry Breaking for Combinatorial Optimisation. *Journal of Artificial Intelligence Research*, 77:1539–1589, August 2023. doi:10.1613/jair.1.14296.
- [2] Jip J. Dekker, Alexey Ignatiev, Peter J. Stuckey, and Allen Z. Zhong. Towards modern and modular sat for lcg. In Maria Garcia de la Banda, editor, *31st International Conference on Principles and Practice of Constraint Programming, CP 2025, August 10-15, 2025, Glasgow, Scotland*, volume 340 of *LIPIcs*. Schloss Dagstuhl - Leibniz-Zentrum für Informatik, 2025.
- [3] Steve Klabnik and Carol Nichols. *The Rust programming language*. No Starch Press, 2023.
- [4] Nicholas Nethercote, Peter J Stuckey, Ralph Becket, Sebastian Brand, Gregory J Duck, and Guido Tack. MiniZinc: Towards a standard CP modelling language. In *International Conference on Principles and Practice of Constraint Programming*, pages 529–543. Springer, 2007.