**FACULTY
OF INFORMATION
TECHNOLOGY
CTU IN PRAGUE**

Review report of a final thesis

Reviewer:	Pierre Donat-Bouillud, Ph.D.
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Thesis title:	An overview of gradual typing approaches in dynamic programming languages
Branch / specialization:	Web and Software Engineering, specialization Software Engineering
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Evaluation criteria

1. Fulfillment of the assignment

[1] assignment fulfilled
▸ **[2] assignment fulfilled with minor objections**
[3] assignment fulfilled with major objections
[4] assignment not fulfilled

The thesis presents an extensive overview of gradual typing in Python, Ruby and PHP, and then gives suggestions on how to add gradual typing to the R language. The overview of gradual typing in Python, Ruby and PHP, is comprehensive and well documented. The recommendations for R are less detailed and not explored in depth but still an interesting starting point.

2. Main written part   95 / 100 (A)

The thesis is very well written, with extremely few typographic and grammar errors. It is well structured, for instance, using the same outline, and the same running example, for the 3 languages. Giving more examples of some of the type constructions would have been helpful though.

Runtime enforcement of types is also part of gradual typing, in some type enforcement strategies. In Python, there are some tools that can check the type annotations at runtime, for instance, enforce, pydantic or pytpes.

In general, references are well cited.
I am not totally sure if there are intersection types for Python (mypy), as claimed in Table 3.4. I was not able to find a reference in the thesis about it.
An issue (#213) of the typing module tracks type intersection prospects. A proposal was written 3 months ago about it. However, a fork of mypy, `basedmypy`, has them. And

recently, `Protocol intersection` (May 2023), protocol intersections were added with the `typing-protocol-intersection` library.

3. Non-written part, attachments   100 / 100 (A)

There are no non-written part (such as code) for that thesis.

4. Evaluation of results, publication outputs and awards   90 / 100 (A)

This thesis amounts to a litterature review. It could be useful for the PRL PRG group, which currently leads effort to retrofit static typing to R. However, in the current state, the recommendations are very generic and not really actionnable.

The overall evaluation   94 / 100 (A)

This thesis is an enjoyable and informative historical, sociological, and technical review of gradual typing, through the example of 3 dynamically-typed languages. The part about recommandations for retrofitting static types to R would benefit from being more precise, showing more actual examples of R code and what kind of types would be useful.

The overview of gradual typing for Python, Ruby and PHP is excellent. It is full of details on the history of how gradual typing was progressively, or suddenly, brought to the language. It has nearly sociological remarks on how a community can start accepting adding static types to a dynamically-typed programming language.
The recommendations for R are not specific enough. I would have appreciated if the running example for Python, Ruby, and PHP (with Vec2D), were reused with a prospective type system for R for instance (without formalizing it, but just to give an idea).

Questions for the defense

- How to boostrap the type definitions for a library (including the standard library of language)? Painstankingly with human beings looking at 100s of functions or classes, or are there automated ways to do it?
- S3 and S4 in R are not the usual OOP based on classes, but uses generic methods. Are there types in Python, Ruby, or PHP, that would be appropriate to type those?

Instructions

Fulfillment of the assignment

Assess whether the submitted FT defines the objectives sufficiently and in line with the assignment; whether the objectives are formulated correctly and fulfilled sufficiently. In the comment, specify the points of the assignment that have not been met, assess the severity, impact, and, if appropriate, also the cause of the deficiencies. If the assignment differs substantially from the standards for the FT or if the student has developed the FT beyond the assignment, describe the way it got reflected on the quality of the assignment's fulfilment and the way it affected your final evaluation.

Main written part

Evaluate whether the extent of the FT is adequate to its content and scope: are all the parts of the FT contentful and necessary? Next, consider whether the submitted FT is actually correct – are there factual errors or inaccuracies?

Evaluate the logical structure of the FT, the thematic flow between chapters and whether the text is comprehensible to the reader. Assess whether the formal notations in the FT are used correctly. Assess the typographic and language aspects of the FT, follow the Dean's Directive No. 52/2021, Art. 3.

Evaluate whether the relevant sources are properly used, quoted and cited. Verify that all quotes are properly distinguished from the results achieved in the FT, thus, that the citation ethics has not been violated and that the citations are complete and in accordance with citation practices and standards. Finally, evaluate whether the software and other copyrighted works have been used in accordance with their license terms.

Non-written part, attachments

Depending on the nature of the FT, comment on the non-written part of the thesis. For example: SW work – the overall quality of the program. Is the technology used (from the development to deployment) suitable and adequate? HW – functional sample. Evaluate the technology and tools used. Research and experimental work – repeatability of the experiment.

Evaluation of results, publication outputs and awards

Depending on the nature of the thesis, estimate whether the thesis results could be deployed in practice; alternatively, evaluate whether the results of the FT extend the already published/known results or whether they bring in completely new findings.

The overall evaluation

Summarize which of the aspects of the FT affected your grading process the most. The overall grade does not need to be an arithmetic mean (or other value) calculated from the evaluation in the previous criteria. Generally, a well-fulfilled assignment is assessed by grade A.