

I. IDENTIFICATION DATA

Thesis title:	Computational trinitarianism and Linear types
Author's name:	Vojtěch Štěpančík
Type of thesis :	bakalářská
Faculty/Institute:	Fakulta elektrotechnická (FEL)
Department:	Katedra počítačů
Thesis reviewer:	Mgr. Marta Bílková, Ph.D.
Reviewer's department:	Institute of Computer Science, the Czech Academy of Sciences

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	A
<i>How demanding was the assigned project?</i>	
The assigned project was quite demanding for a bachelor thesis. First of all, this is a theoretical thesis. The chosen topic connects three closely related, but distinct disciplines: logic (namely, structural proof theory), type theory (namely, simply typed lambda calculus and linear types), and category theory (namely, cartesian closed categories and symmetric monoidal closed categories). This means that the author needed to gain sufficient understanding in all the three disciplines and formalisms involved, as well as how exactly they connect.	

Fulfilment of assignment	A
<i>How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.</i>	
The goal of the thesis, as I understand it, was to explain how the well-known Curry-Howard correspondence between intuitionistic (constructive) proofs and lambda terms (programs) in simply typed lambda calculus extends into linear logic. This has been achieved. Moreover, the thesis explains the correspondence for (a fragment) of linear logic in closed connection with that for intuitionistic logic via a translation of IL into LL, and the whole picture is complemented with the categorial semantics of intuitionistic and linear programs in the spirit of Computational trinitarianism.	

Methodology	A
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
Methodology aspects of the thesis are in full accord with those standardly used in the three mathematical fields mentioned above, and all the methods and formalisms are used properly. It is clear from the thesis that the author understands the methods (including natural deduction proofs, lambda term notation, and the language of category theory).	

Technical level	A
<i>Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?</i>	
The thesis is technically sound, the formal material is laid out very clearly and in a proper consecutive order, no essential details are missing, and examples to illustrate the problematic points are provided. I would like to stress that the topic of the thesis is highly abstract and therefore rigidity and consistency in notation is essential to present it. The challenge is to do so in an understandable manner, which the thesis achieved.	

Formal and language level, scope of thesis	A-
<i>Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?</i>	
As I have already mentioned above, the formalisms are standard and are used properly in the thesis. I appreciate the thesis being written in good English.	

The thesis is organized into three chapters highlighting the computational trinitarianism - Logic, Type Theory, and Category Theory - and within each chapter the material is laid out in a natural order concerning the thesis narrative. The material itself is very clearly presented, the level of details is well-balanced, everything is clearly defined and all the claims are proven.

I have some minor critical points to make here though, relevant for further writing:

1. I would prefer if there was a more extensive Introduction section to the whole thesis. There the author could for example explain computational trinitarianism, the origins of the term, its importance, and put it in a bit of historical context of the development of computer science. Also, here is the place where you make clear the thesis contribution, and what the text is meant to be (e.g. survey or original paper) and where to place it in the context of the relevant literature on the topic.
2. There also could have been a Conclusion section, simply summing up what the reader can take away from the thesis, and pointing out at its limits - the material which is out of the scope of the thesis, but highly relevant and interesting.
3. Last but not least, I would very much prefer the text to be formally structured into Definitions, Claims or Theorems, and Proofs. Although nothing of those is actually missing in the thesis, it is not structured quite this way. I do not vote for the extreme: a lot of inter-connecting text and explanations should of course be there to make the reading fluent, but formal structuring makes cross-referencing in the thesis, and referencing to particular places in it, much easier.

Selection of sources, citation correctness

A

Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?

The thesis refers to the relevant literature in the proper way. I found the choice of references adequate for what the thesis is about.

Additional commentary and evaluation (optional)

Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.

The thesis does not present new results, but it was not the goal. The thesis however very clearly presents the connection between linear logic and computation (which is not so well-known in contrast with the Curry-Howard correspondence for intuitionistic logic).

Some minor additional comments and typos:

- When you define natural deduction proofs, you can mention they are finite (p. 4)
- In the case of intuitionistic logic you use judgements "A true". One could stress here that in intuitionistic logic the judgement is more about A being proven constructively than about A being objectively true (p. 6). This correspond well with what you say about there being an appropriate term (i.e. a proof of A) (p. 22).
- In the pictures of reductions, I would consider to some notation indicating that we are using an instance of a proof s, say $s[A / \Delta]$ (starts at p. 8).
- When you introduce bang ! operator on (p. 9), you may say that it is sometimes called an "of course" operator (cf. with its dual ? being called "why not" operator).
- When you say "Intuitionistic assumptions are another way of modeling free resources" (p. 12), you can make a point on proofs being a free resource (proofs are duplicable).
- The translation operator on judgments (top of p. 14): there should be

$$\llbracket A \text{ prop} \rrbracket_L = \llbracket A \rrbracket_{\text{prop}}$$

$$\llbracket A \text{ true} \rrbracket_L = \llbracket A \rrbracket_{\text{true}}$$
- Figure 2.1. (p. 20): I would stress that x in Weakening and z in Contraction rules are assumed to be fresh.
- on (p. 22), I would add a reference for Curry-Howard correspondence. You may also explain that it is "formulas as types" and "terms as proofs" correspondence.

- “We give a worked example” → “We give a working example” (p. 39 middle).
In the diagram right below this, say what the map f is.
- the xE rules (p. 41 middle): in xE_2 rule, there should be a B in the conclusion.
- When you talk about adjoint functors (p. 42 middle), you may observe that this corresponds to a similar property of conjunction and implication connectives in logic, called residuation.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

To sum up, this is an excellent bachelor thesis. The topic is a theoretical one, and it required, before even the writing started, to understand the idea of three distinct and highly abstract theories. The goal of the thesis is to explain computational trinitarianism, and it has been achieved in an approachable way (the text could for example serve as a part of lecture notes on the topic).

Questions for the defense (to be freely chosen from):

1. Explain computational trinitarianism, and the origins of the term.
2. You say “We have not specified what η -conversions correspond to in logic” (p. 32). Does it correspond to anything?
3. You say “We do not attempt to give interpretations to the $!!$ and $!E$ rules, ... as the difficulty of this problem is far beyond the level of a bachelor's thesis” (bottom of p. 43). Can you at least hint at what is the challenge here?

The grade that I award for the thesis is

A

Date: **4.6.2021**

Signature: