

First Committee Meeting

Progress Report

Jason Balaci

McMaster University

Oct. 21st, 2021

Table of Contents

1 Introduction

2 Project

- Drasil
- Goal #1: Typed Expression Language
- Goal #2: Theory Discrimination – “ModelKinds”

3 References

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Who am I?

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Me, Camping in Killarney Prov.
Park, Fall 2019

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- Graduate of *McMaster University*, holding...
 - Hons. Actuarial and Financial Mathematics (B.Sc.)
 - Minor in Computer Science
- Currently pursuing a thesis-based Master's of Computer Science (M.Sc) at *McMaster University*, under the supervision of **Dr. Jacques Carette**.



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Overview of Progression Towards C.S. M.Sc.

Course-related progression

- I'm required to complete¹²:

¹https://academiccalendars.romcmaster.ca/preview_program.php?catoid=45&poid=23470&returnto=9166

²http://www.cas.mcmaster.ca/cas/0files/reg_master_cs_2019a.pdf

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 - CAS 763 "Certified Programming with Dependent Types" - Theory & Software course, Winter 2021

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- Together, the courses completed satisfies the "Courses Requirement" as mentioned in the academic calendar¹ and the "Regulations for the Computer Science M.Sc. Program" document².

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- Supervisory committee is formed, and we are currently having our first supervisory committee meeting.
 - *Supervisor:* Dr. Jacques Carette
 - Dr. Spencer Smith
 - Dr. Wolfram Kahl

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Drasil...



Drasil's Logo

[Carette et al., 2021b][Yggdrasil - Wikipedia, 2021]

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- has a website¹!



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Drasil

“Generate All The Things!”

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- Drasil currently focuses on building research software, with Software Requirement Specification documents (SRS) in both LaTeX and HTML (with MathJaX), code to solve a problem, README files, Makefiles, graphs, etc.

Drasil Case Studies

¹<https://jacquescarette.github.io/Drasil/#Sec:Examples>

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 - **Solar Water Heating System (SWHS)** - Modelling of a solar water heating system with phase change material, predicting temperatures and change in heat energy of water and the PCM over time.

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- *cont.d*¹:
 - **SWHS without Phase Change Material (NoPCM)** - Modelling of a solar water heating system without phase change material, predicting temperatures and change in heat energy of water and the PCM over time.

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- **Slope Stability Analysis Program (SSP)** - Assessment of the safety of a slope (composed of rock and soil) subject to gravity, identifying the surface most likely to experience slip and an index of its relative stability (factor of safety).

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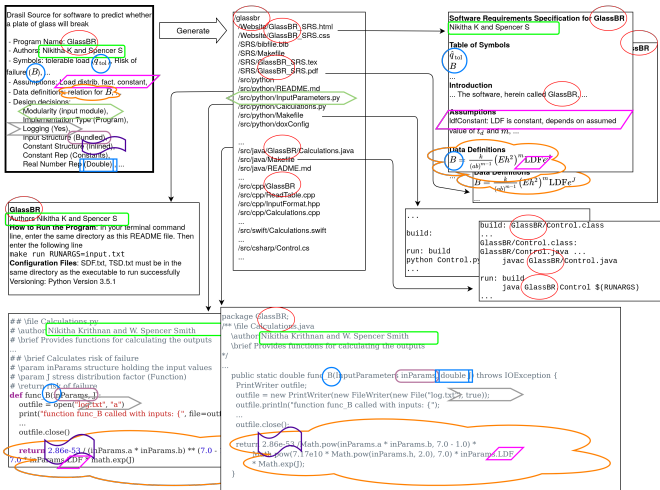
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The Drasil website is also generated by Drasil!

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Taking a closer look at one of the examples: GlassBR

GlassBR Generates Code!



Knowledge flow from “knowledge-base”/source to artifacts, by Dr. Spencer Smith

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- Confidently generating usable software artifacts without strong type information places significant stress on developers, resulting in a higher likelihood of bugs in artifacts.
- Existing “theories”/“*Models”¹ don't expose enough information. They must be enriched, so that we can better interact with, and understand them.

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Goal #1: Typed Expression Language

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- We want to ease developer cognitive load when writing expressions, as they will need to ensure their expressions are coherent, or else a type error can occur at runtime.

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- Allows GOOL code generator to also become typed!
- Add extra functionality to existing expression languages safely, allowing for new data types to be introduced.
- Adding type information to expressions shouldn't be a burden!

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 - Theories that rely on discussion of terms only found “ModelExpr” may only have code generated for them if we have rich enough data (see goal #2).
 - “CodeExpr” is a clone of ‘Expr’, with a few extra functionalities for GOOL.

Goal #1: Typed Expression Language

Current Progression

- Split core mathematical expression language (Expr) into 3 variants (Expr, ModelExpr, and CodeExpr)
 - ‘Expr’ is a discrete, directly computable language, expected to have a *total* conversion into code (e.g., calculator).
 - Created ‘ModelExpr’, which contains all other kinds of expressions we might want to express, but won’t necessarily be directly convertible into code. There are still a few operations left in “Expr” that need to be moved over, however.
 - Theories that rely on discussion of terms only found “ModelExpr” may only have code generated for them if we have rich enough data (see goal #2).
 - “CodeExpr” is a clone of ‘Expr’, with a few extra functionalities for GOOL.
 - Created a typed tagless final[Carette et al., 2009] smart constructor encoding for writing expressions in “Expr” (or, optionally, ModelExpr).

Goal #1: Typed Expression Language

What are the next steps?

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- Continue moving inadmissible terms from “Expr” into “ModelExpr”.

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- Continue moving inadmissible terms from “Expr” into “ModelExpr”.
- Moving literals from “Expr” & “ModelExpr” into their own small language, so that areas that want *strictly* literals can also have stronger restrictions on allowed data.

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- Continue moving inadmissible terms from “Expr” into “ModelExpr”.
- Moving literals from “Expr” & “ModelExpr” into their own small language, so that areas that want *strictly* literals can also have stronger restrictions on allowed data.
- Adjusting containers to allow for expressions with a type variable.

Goal #1: Typed Expression Language

What are the next steps?

- Continue moving inadmissible terms from “Expr” into “ModelExpr”.
- Moving literals from “Expr” & “ModelExpr” into their own small language, so that areas that want *strictly* literals can also have stronger restrictions on allowed data.
- Adjusting containers to allow for expressions with a type variable.
- Adding the final type signatures, using Haskell GADT syntax.

Goal #2: Theory Discrimination – “ModelKinds”

Problem Description

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- “RelationConcepts” were heavily used in both displaying expressions, and code generation. They are essentially “Relation”s (“Expr”s) with a natural language description of them.

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Problem Description

- “RelationConcepts” were heavily used in both displaying expressions, and code generation. They are essentially “Relation”s (“Expr”s) with a natural language description of them.
- “RelationConcept”s don’t contain enough information on their own to be a core component usable in general code generation.
- If the “shape” of the expressions are not uniform, then writing more “interpreters”/“views”/code generators for them required difficult pattern analysis. It’s also not a total-conversion.

Goal #2: Theory Discrimination – “ModelKinds”

What makes up a “good” solution?

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- A good solution involves making the “Relation”s a “view” of a more data-rich specialized container for each kind of “Theory”/“*Model”.

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- By constructing our final data views through “more steps” (e.g., with more depth), we obtain a better understanding of our “theories”, allowing us to do more with them.

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What makes up a “good” solution?

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- “ModelKinds”
- By constructing our final data views through “more steps” (e.g., with more depth), we obtain a better understanding of our “theories”, allowing us to do more with them.
- We should be able to easily add extra “ModelKind” variants.

Goal #2: Theory Discrimination – “ModelKinds”

Current Progression

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- All “RelationConcepts” have been replaced, with one of:

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- All “RelationConcepts” have been replaced, with one of:
 - EquationalModels: “QDefinition”s

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Current Progression

- All “RelationConcepts” have been replaced, with one of:
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 - EquationalRealms: “MultiDefn”s

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- All “RelationConcepts” have been replaced, with one of:
 - EquationalModels: “QDefinition”s
 - EquationalRealms: “MultiDefn”s
 - EquationalConstraints: “ConstraintSet”s

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 - DEModels: “RelationConcept”s

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 - DEModels: “RelationConcept”s
 - OthModels: “RelationConcept”s

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- Considerable number of “theories”/“*Models” have been restructured, but there are still many that are pending classification.

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Current Progression

- All “RelationConcepts” have been replaced, with one of:
 - EquationalModels: “QDefinition”s
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 - EquationalConstraints: “ConstraintSet”s
 - DEModels: “RelationConcept”s
 - OthModels: “RelationConcept”s
- Considerable number of “theories”/“*Models” have been restructured, but there are still many that are pending classification.
 - Most are best to be done once we have a typed expression language (so that we can better handle expressions that involve collections of sorts), and the rest are differential equation-related models (primarily Dong’s domain).

Goal #2: Theory Discrimination – “ModelKinds”

What are the next steps?

Goal #2: Theory Discrimination – “ModelKinds”

What are the next steps?

- Understanding what kinds of needs we have for “collections”, pushing this information back into the typed expression language (once that is fully typed), and then creating model containers for these models.

Goal #2: Theory Discrimination – “ModelKinds”

What are the next steps?

- Understanding what kinds of needs we have for “collections”, pushing this information back into the typed expression language (once that is fully typed), and then creating model containers for these models.
- For the differential equation-related models, we will need to build appropriate models for each possible kind.

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- Both goals are as designated by Dr. Carette, Dr. Smith, and past (and present) Drasil authors.
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Fin.
Thank you!

Table of Contents

1 Introduction

2 Project

- Drasil
- Goal #1: Typed Expression Language
- Goal #2: Theory Discrimination – “ModelKinds”

3 References

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