First Committee Meeting

Progress Report

Jason Balaci

McMaster University

Oct. 21^{st}, 2021

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Who am I?

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- I am **Jason Balaci**

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 complete[1][2]:

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

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- Together, the courses completed satisfies the "Courses Requirement" as mentioned in the academic calendar[1] and the "Regulations for the Computer Science M.Sc. Program" document[2].

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- Attended a thesis defence to learn about what to expect from a thesis defence (and learn about their research).

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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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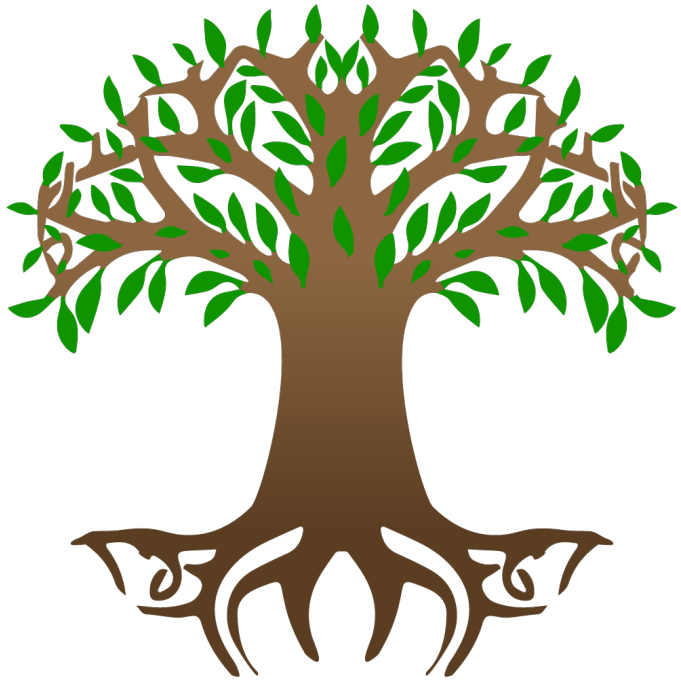
Drasil...



Drasil's Logo
[Carette et al., 2021][Yggdrasil - Wikipedia, 2021]

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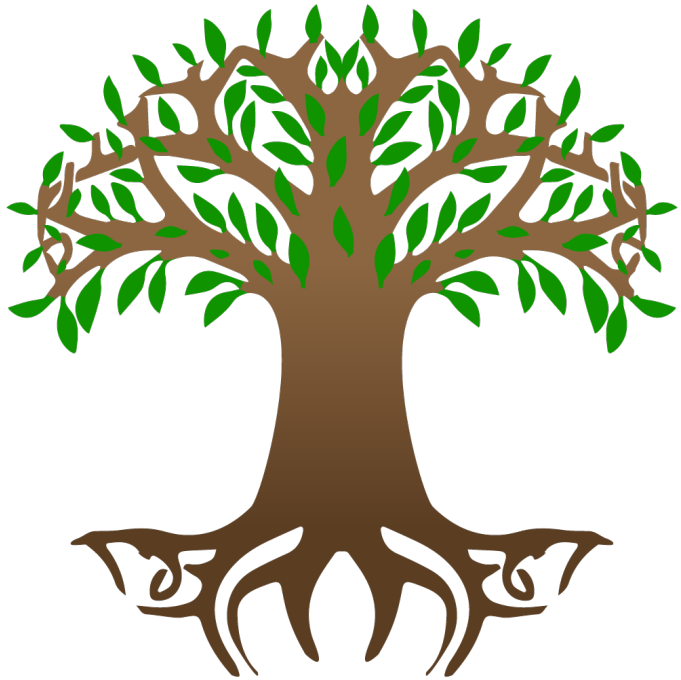

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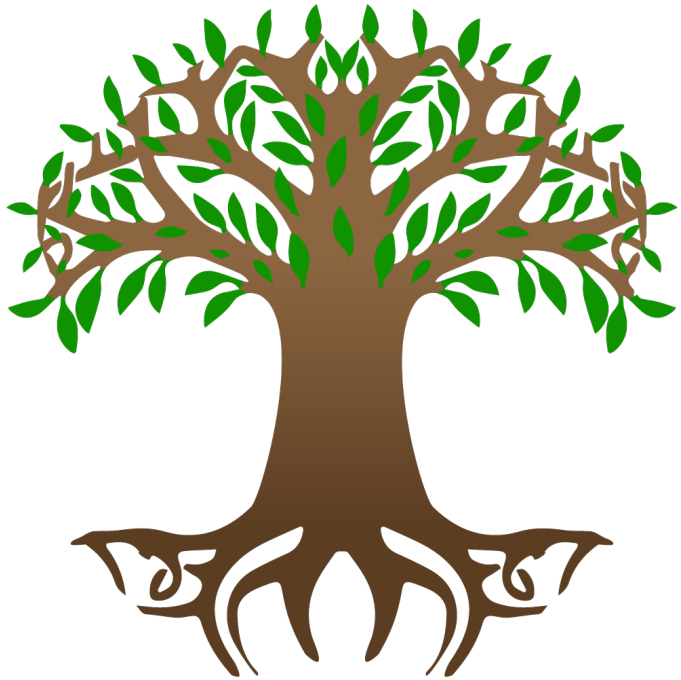

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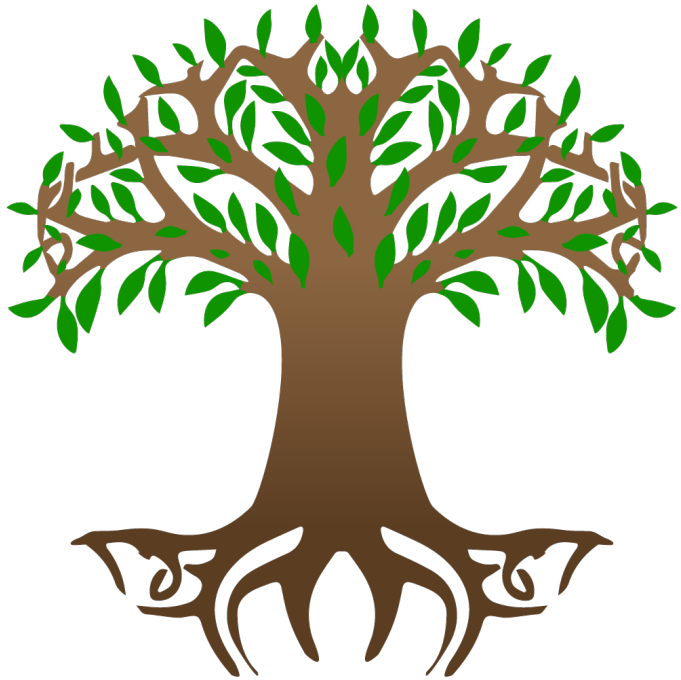

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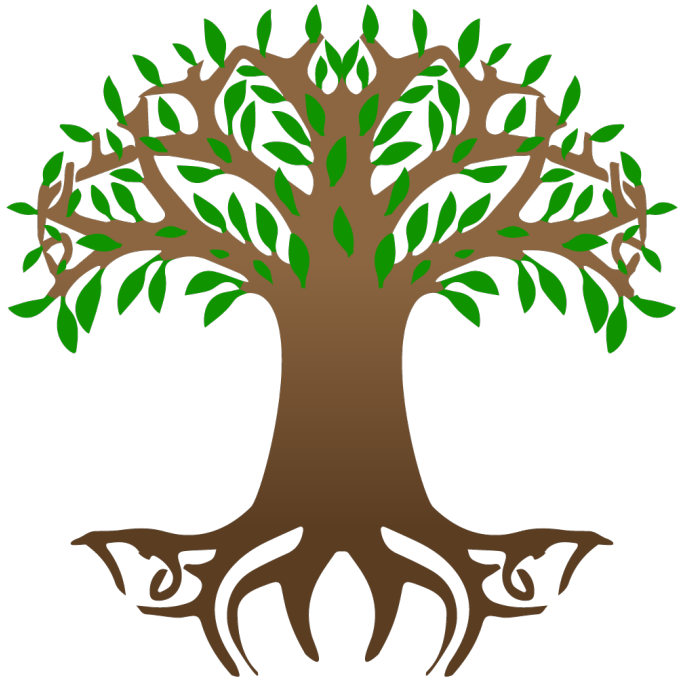

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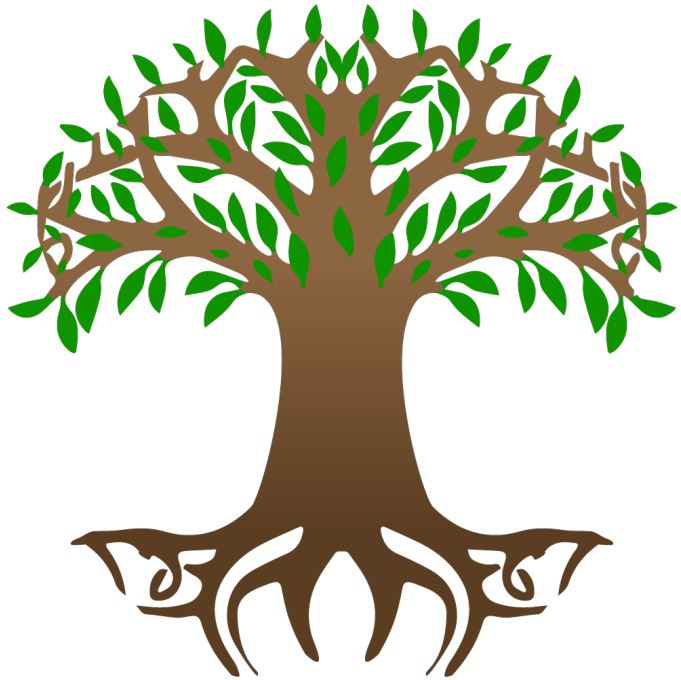

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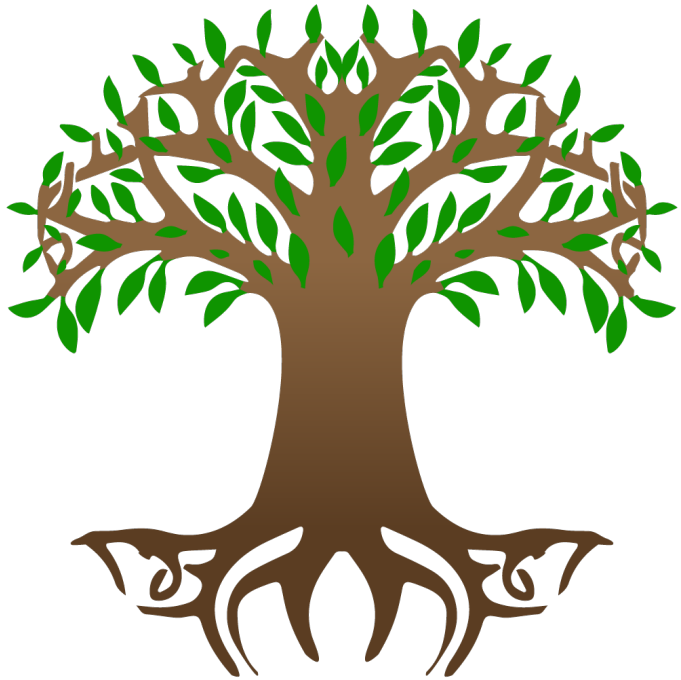

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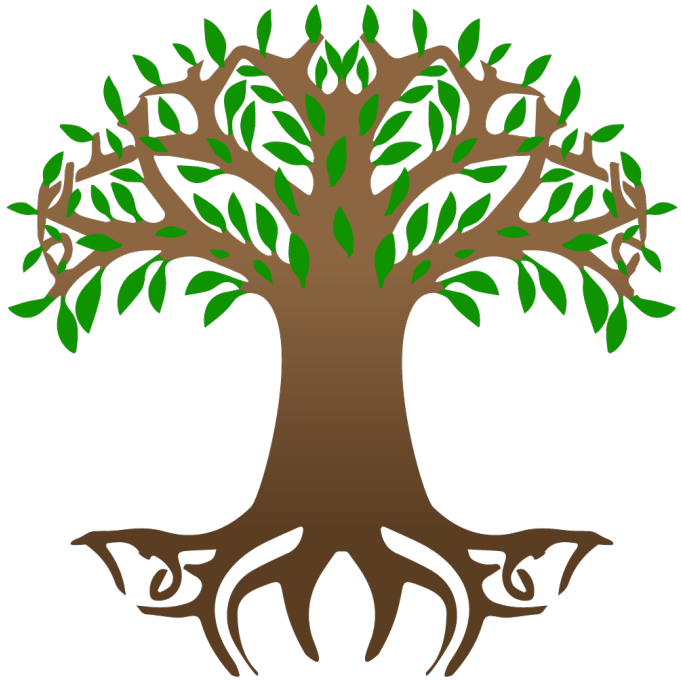

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  - Knowledge organization and capture is of utmost importance, as it is the pathway for interpreters and Domain-Specific Languages (DSLs) to make appropriate usage of the knowledge captured.

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  - Knowledge organization and capture is of utmost importance, as it is the pathway for interpreters and Domain-Specific Languages (DSLs) to make appropriate usage of the knowledge captured.
  - By creating different kinds of "printers", we can use a stable knowledge-base to generate software that solves "well understood" problems.

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  - By creating different kinds of "printers", we can use a stable knowledge-base to generate software that solves "well understood" problems.
- 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.

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Drasil Case Studies

- *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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The Drasil website is also generated by Drasil!

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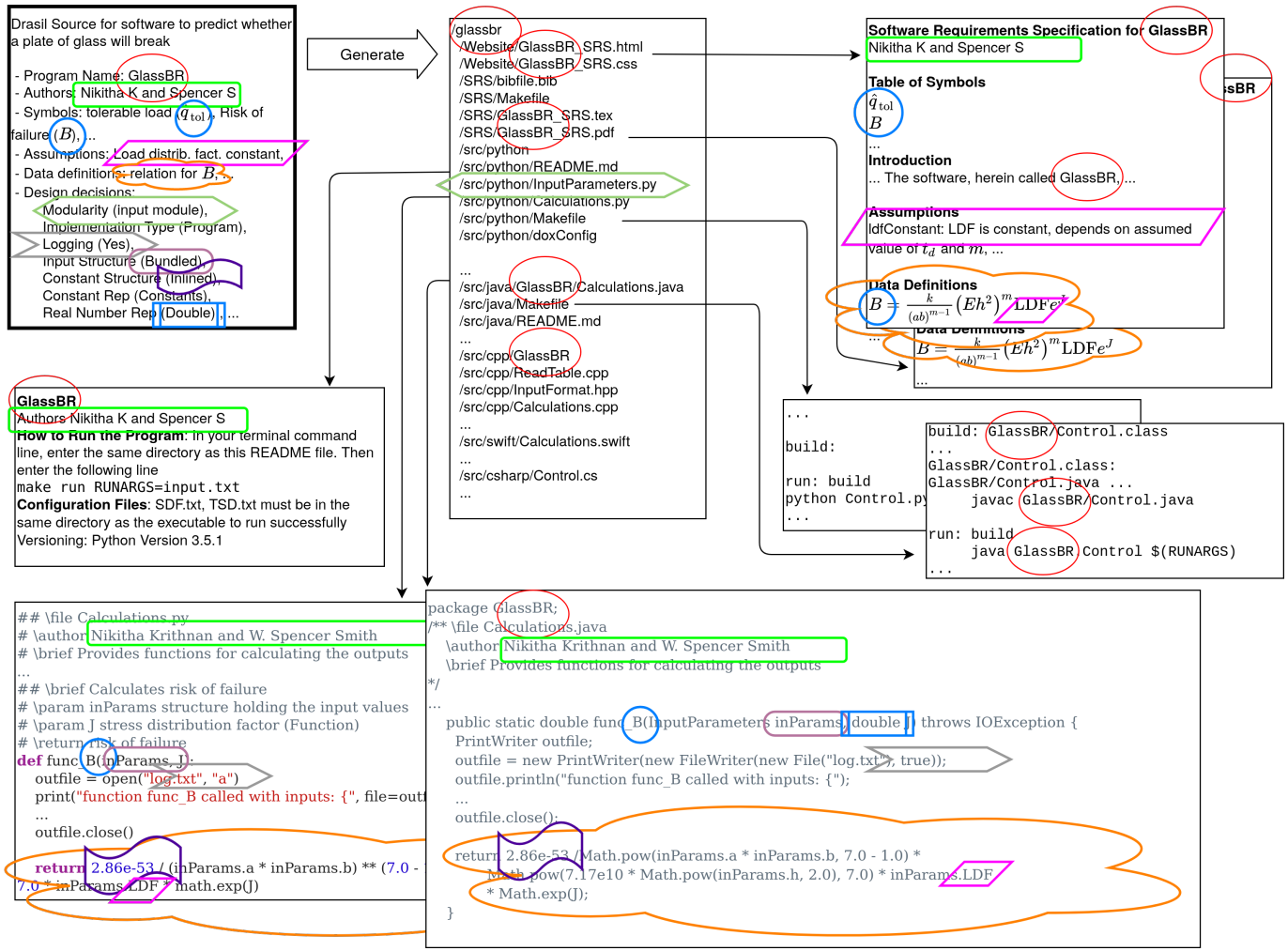
Taking a closer look at one of the examples: GlassBR

GlassBR Generates Code!



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

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A few, notable, blocking problems:

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A few, notable, blocking problems:

- 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.

[1] Terminology is currently being changed, but is not reflected in many documents yet.

Goal #1: Typed Expression Language

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- Ensure only admissible expressions are used in GOOL-supported languages, and that all expressions are coherent.
- 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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- Add extra functionality to existing expression languages safely, allowing for new data types to be introduced.

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- Catches, within reason, all possible scenarios where an expression goes awry.
- 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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  - "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).

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- 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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- Adjusting containers to allow for expressions with a type variable.
- Adding the final type signatures, using Haskell GADT syntax.

Goal #2: Theory Discrimination – "ModelKinds"

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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.

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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.
- We should be able to easily add extra "ModelKind" variants.

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- 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?

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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.

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- 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.

Fin.

Thank you!

Table of Contents

References I


Carette, J., Kiselyov, O., and Shan, C.-c. (2009).
Finally tagless, partially evaluated: Tagless staged interpreters for simpler typed languages.
Journal of Functional Programming, 19(5):509–543.


Carette, J., Smith, S., Balaci, J., Hunt, A., Wu, T.-Y., Crawford, S., Chen, D., Szymczak, D., MacLachlan, B., Scime, D., and Niazi, M. (2021).
Drasil.


Yggdrasil - Wikipedia (2021).
Yggdrasil.