

DRASIL

A Knowledge-Based Approach to Scientific Software Development

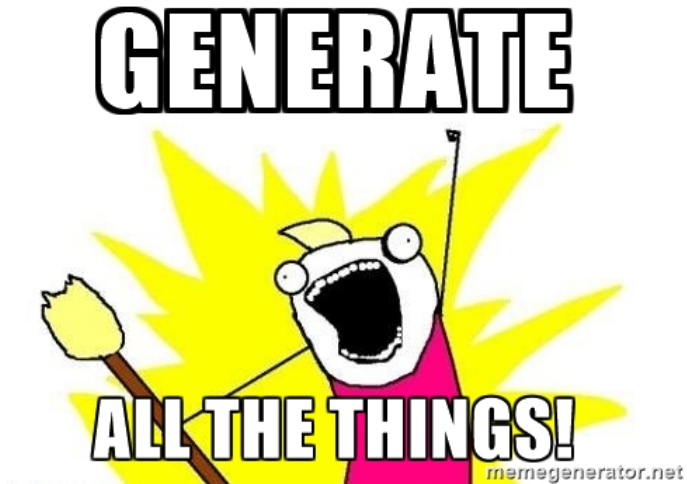
Henry M, Aaron M, Maryyam N, Nicholas R, Dan S

McMaster University

Literate Scientific Software Group, July 27, 2017

Background Context

- \exists problems $\in D$ where
- $D = \{ \text{scientific computing, engineering computing} \}$
- Problems = [
 - Inconsistent Software Requirement Specifications (SRS) across D
 - Inconsistency between code and documentation
 - Documentation is annoying to make and maintain
 - Hard to reuse code for different applications]



Purpose of Drasil

- Solve the four problems
- Promote
 - Reusability
 - Examples have fully documented code
 - Data base to build new examples
 - Maintainability
 - Make changes in one place, gets updated everywhere

What is Drasil?

- Knowledge Capture (Data.Drasil)

What is Drasil?

- Knowledge Capture (Data.Drasil)
- Language and Rendering (Language.Drasil)
 - Code Generation: transition from Drasil to working code
 - Documentation Generation: transition from Drasil to human readable documentation

What is Drasil?

- Knowledge Capture (Data.Drasil)
- Language and Rendering (Language.Drasil)
 - Code Generation: transition from Drasil to working code
 - Documentation Generation: transition from Drasil to human readable documentation
- Case Studies (Example.Drasil)
 - This part is where you would input equations, requirements, and output code and documentation

- Input:

- Input:
 - Equations (DataDefs, Instance Models)

- Input:
 - Equations (DataDefs, Instance Models)
 - Requirements

- Input:
 - Equations (DataDefs, Instance Models)
 - Requirements
 - Assumptions

- Input:
 - Equations (DataDefs, Instance Models)
 - Requirements
 - Assumptions
- Output:

- Input:
 - Equations (DataDefs, Instance Models)
 - Requirements
 - Assumptions
- Output:
 - Code that fits the requirements and assumptions

- Input:
 - Equations (DataDefs, Instance Models)
 - Requirements
 - Assumptions
- Output:
 - Code that fits the requirements and assumptions
 - Documentation (Module Guide, Software Requirements Specification)

Errors in Drasil?

- Catching and correcting errors in software:

Errors in Drasil?

- Catching and correcting errors in software:
 - If there is an error, it will be everywhere

Errors in Drasil?

- Catching and correcting errors in software:
 - If there is an error, it will be everywhere
 - Easy to spot

Errors in Drasil?

- Catching and correcting errors in software:
 - If there is an error, it will be everywhere
 - Easy to spot
 - Once it's fixed, it is also fixed everywhere else

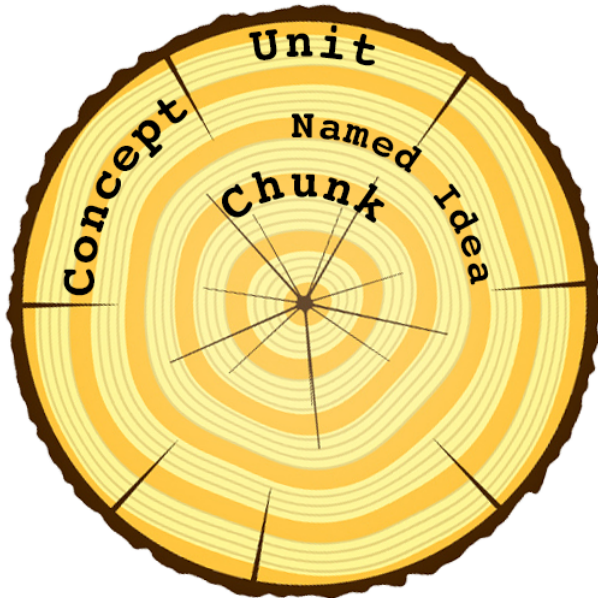
- Drasil is a knowledge capturing system that allows for the easy reuse of information

- Drasil is a knowledge capturing system that allows for the easy reuse of information
- Knowledge capture is achieved through the use of data types called chunks

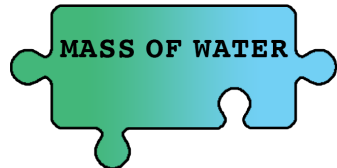
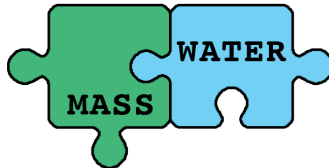
- Drasil is a knowledge capturing system that allows for the easy reuse of information
- Knowledge capture is achieved through the use of data types called chunks
- Combination of chunks to grow information

- Drasil is a knowledge capturing system that allows for the easy reuse of information
- Knowledge capture is achieved through the use of data types called chunks
- Combination of chunks to grow information
- Related information should stem from one source (reduces duplication)

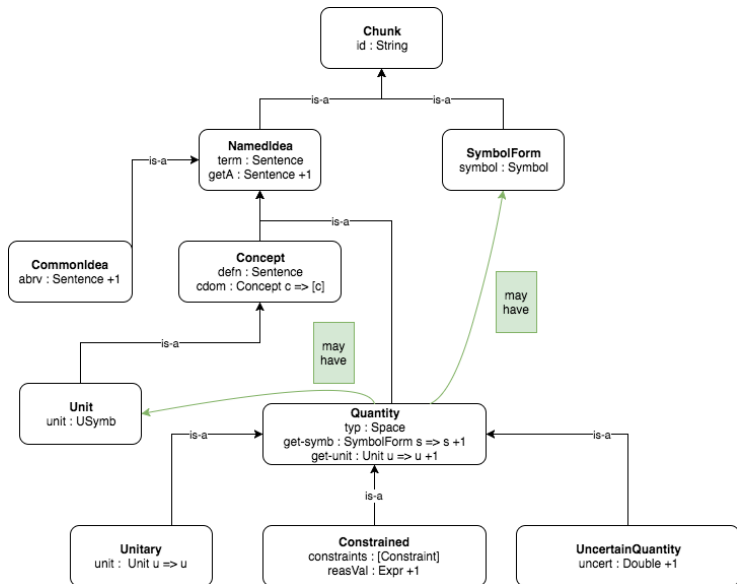
Growing Chunk



Chunk Combinations



Drasil Logic Tree



Collaborative Efforts

- Peer review of code

Collaborative Efforts

- Peer review of code
- Discussion of all around issues (ex. cyclic imports, referencing problems)

Collaborative Efforts

- Peer review of code
- Discussion of all around issues (ex. cyclic imports, referencing problems)
- A lot of collaboration through GitHub



GitHub

Collaboration via Github

Git is a version control system, GitHub is a Git repository hosting service that is **free**.

- Git allows us to collaborate effectively, even when team members are not in the same location

☐  **Unify Data Definitions automation for Theoretic**
enhancement

#29 opened on Jun 1, 2016 by smiths  0.1.0

☐  **Notes in tables** **Low Priority**

#26 opened on May 30, 2016 by bmaclach  0.1.5

☐  **Units in Data Definition descriptions** **Design**

#24 opened on May 30, 2016 by bmaclach  0.1.0

☐  **Unify Data Definitions automation for Theoretic**
enhancement

#29 opened on Jun 1, 2016 by smiths  0.1.0

☐  **Notes in tables** **Low Priority**

#26 opened on May 30, 2016 by bmaclach  0.1.5

☐  **Units in Data Definition descriptions** **Design**

#24 opened on **May 30, 2016** by bmaclach  0.1.0

Collaboration via Github

Git is a version control system, GitHub is a Git repository hosting service that is **free**.

- Git allows us to collaborate effectively, even when team members are not in the same location
- Git combined with Haskell, allows us to make large changes while easily maintaining a working version of Drasil

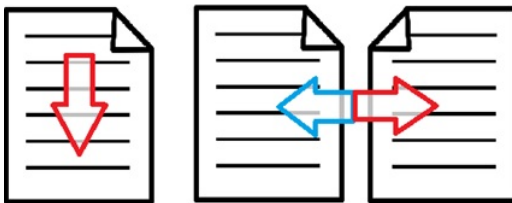
Collaboration via Github

Git is a version control system, GitHub is a Git repository hosting service that is **free**.

- Git allows us to collaborate effectively, even when team members are not in the same location
- Git combined with Haskell, allows us to make large changes while easily maintaining a working version of Drasil
- Git (**when used properly**) prevents catastrophic loss of work

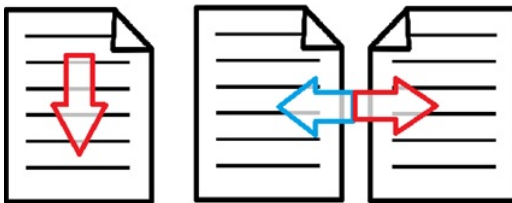
Daily Tasks

- Finding patterns within examples \Rightarrow sentence combinators
- Finding patterns between examples \Rightarrow extraction of common sections, contents, and concepts



Daily Tasks

- Finding patterns within examples \Rightarrow sentence combinators
- Finding patterns between examples \Rightarrow extraction of common sections, contents, and concepts



- Knowledge extraction
- Reduced duplication due to
 - Increased function efficiency
 - Building chunks off of each other instead of from scratch

Example

Var	Physical Constraints	Software Constraints	Typical Value	Typical Uncertainty
P_{btol}	$0.0 < P_{btol}$ and $P_{btol} < 1.0$	None	0.008	1.0e-3
TNT	$TNT > 0.0$	None	1	0.1
a	$a > 0.0$ and $\frac{a}{b} > 1.0$	$d_{min} \leq a$, $a \leq d_{max}$, and $\frac{a}{b} < AR_{max}$	1500.0 m	0.1
b	$b > 0.0$ and $b < a$	$d_{min} \leq b$, $b \leq d_{max}$, and $\frac{a}{b} < AR_{max}$	1200.0 m	0.1
w	$w \geq 0.0$	$w_{max} \leq w$ and $w \leq w_{min}$	42.0 kg	0.1
SD	$SD > 0.0$	$SD_{min} < SD$ and $SD < SD_{max}$	45.0 m	0.1

Input Data Constraints

Example

```
s6_2_5_table1 = Table [S "Var", S "Physical Cons", S "Software Constraints", S "Typical Value",  
  S "Uncertainty"] (mkTable [(\x -> x!!0), (\x -> x!!1), (\x -> x!!2), (\x -> x!!3),  
  (\x -> x!!4)] [(P $ plate_len ^ . symbol), (P $ plate_len ^ . symbol) +:+ S "> 0 and" +:+  
  (P $ plate_len ^ . symbol) +:+ S "/" +:+ (P $ plate_width ^ . symbol) +:+ S "> 1",  
  (P $ dim_min ^ . symbol) +:+ S "<=" +:+ (P $ plate_len ^ . symbol) +:+ S "<=" +:+  
  (P $ dim_max ^ . symbol) +:+ S "and" +:+ (P $ plate_len ^ . symbol) +:+ S "/" +:+  
  (P $ plate_width ^ . symbol) +:+ S "<" +:+ (P $ ar_max ^ . symbol), S "1500" +:+  
  Sy (unit_symb plate_len), S "10%"], [(P $ plate_width ^ . symbol),  
  (P $ (plate_width ^ . symbol)) +:+ S "> 0 and" +:+ (P $ plate_width ^ . symbol)  
  +:+ S "<" +:+ (P $ plate_len ^ . symbol), (P $ dim_min ^ . symbol) +:+ S "<=" +:+  
  (P $ plate_width ^ . symbol) +:+ S "<=" +:+ (P $ dim_max ^ . symbol) +:+ S "and" +:+  
  (P $ plate_len ^ . symbol) +:+ S "/" +:+ (P $ plate_width ^ . symbol) +:+ S "<" +:+  
  (P $ ar_max ^ . symbol), S "1200" +:+ Sy (unit_symb plate_width), S "10%"],  
  [(P $ pb_tol ^ . symbol), S "0 <" +:+ (P $ pb_tol ^ . symbol) +:+ S "< 1", S "-", S "0.008", S "0.1%"],  
  [(P $ char_weight ^ . symbol), (P $ char_weight ^ . symbol) +:+ S ">= 0", (P $ cWeightMin ^ . symbol)  
  +:+ S "<" +:+ (P $ char_weight ^ . symbol) +:+ S "<" +:+ (P $ cWeightMax ^ . symbol), S "42" +:+  
  Sy (unit_symb char_weight), S "10%"], [(P $ tNT ^ . symbol), (P $ tNT ^ . symbol) +:+  
  S "> 0", S "-", S "1", S "10%"], [(P $ standOffDist ^ . symbol), (P $ standOffDist ^ . symbol)  
  +:+ S "> 0", (P $ sd_min ^ . symbol) +:+ S "<" +:+ (P $ standOffDist ^ . symbol) +:+ S "<" +:+  
  (P $ sd_max ^ . symbol), S "45" +:+ Sy (unit_symb standOffDist), S "10%"]])
```



```
s6_2_5_table1 :: Contents  
s6_2_5_table1 = inDataConstTbl (gbInputDataConstraints)
```

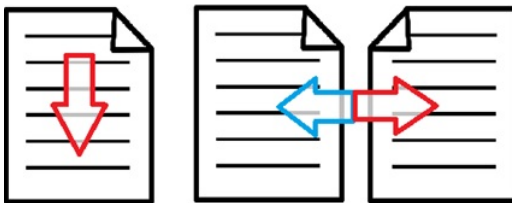
Example

```
plate_len :: UncertQ
plate_len = uqcND "plate_len" (nounPhraseSP "plate length (long dimension)")
  1A metre Real
  [ physc $ \c -> c :> (Dbl 0),
    physc $ \c -> (c / (C plate_width)) :> (Dbl 1),
    sfwrc $ \c -> (C dim_min) :<= c,
    sfwrc $ \c -> c :<= (C dim_max),
    sfwrc $ \c -> (c / (C plate_width)) :< (C ar_max) ] (Dbl 1500) defaultUncrt
```

```
-- Creates the input Data Constraints Table
inDataConstTbl :: (UncertainQuantity c, SymbolForm c, Constrained c) => [c] -> Contents
inDataConstTbl qlst = Table ([S "Var"] ++ (isPhys $ physC (head qlst) qlst) ++
  (isSfwr $ sfwrC (head qlst) qlst) ++ [S "Typical" ++ titleize value] ++
  (isUnc $ typUnc (head qlst) qlst))
  (map (\x -> fmtInputConstr x qlst) qlst)
  (S "Input Data Constraints") True
where isPhys [] = []
      isPhys _ = [titleize' physicalConstraint]
      isSfwr [] = []
      isSfwr _ = [titleize' softwareConstraint]
      isUnc [] = []
      isUnc _ = [S "Typical Uncertainty"]
```

Daily Tasks

- Finding patterns within examples \Rightarrow sentence combinators
- Finding patterns between examples \Rightarrow extraction of common sections, contents, and concepts



- Knowledge extraction
- Reduced duplication due to
 - Increased function efficiency
 - Building chunks off of each other instead of from scratch
- Implement new functions/types created by supervisors

Daily Tasks

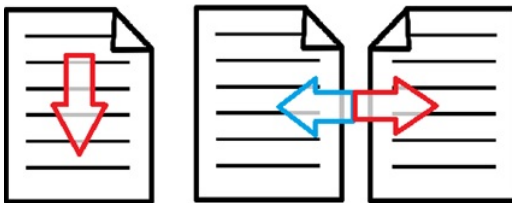
- Finding patterns within examples \Rightarrow sentence combinators
- Finding patterns between examples \Rightarrow extraction of common sections, contents, and concepts



- Knowledge extraction
- Reduced duplication due to
 - Increased function efficiency
 - Building chunks off of each other instead of from scratch
- Implement new functions/types created by supervisors
- Code cleanup and bug fixing

Daily Tasks

- Finding patterns within examples \Rightarrow sentence combinators
- Finding patterns between examples \Rightarrow extraction of common sections, contents, and concepts



- Knowledge extraction
- Reduced duplication due to
 - Increased function efficiency
 - Building chunks off of each other instead of from scratch
- Implement new functions/types created by supervisors
- Code cleanup and bug fixing
- Opening/closing issues

Case Study Contributions

- Each member is assigned a case study as well as tasks and issues
- SWHS
 - Largest Example
 - ODEs

Case Study Contributions

- Each member is assigned a case study as well as tasks and issues
- SWHS
 - Largest Example
 - ODEs
- NoPCM
 - Builds off of pre-existing SWHS example

Case Study Contributions

- Each member is assigned a case study as well as tasks and issues
- SWHS
 - Largest Example
 - ODEs
- NoPCM
 - Builds off of pre-existing SWHS example
- GlassBR
 - Omitted general definitions

Case Study Contributions

- SSP
 - Indexing
 - Sophisticated math
 - Diversity of symbols

Case Study Contributions

- SSP
 - Indexing
 - Sophisticated math
 - Diversity of symbols
- GamePhysics
 - Most ambiguous example
 - SRS for a game physics library

For more information about Drasil and LLS visit our github page:
<https://github.com/JacquesCarette/literate-scientific-software>

You can even build a working version yourself!

