Literate Software and the Drasil Framework

Dan Szymczak

Computing and Software Department
Faculty of Engineering
McMaster University

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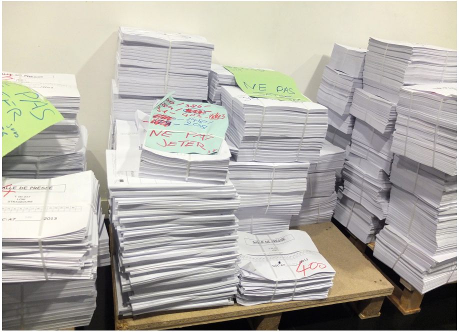
Literate Software and Drasil

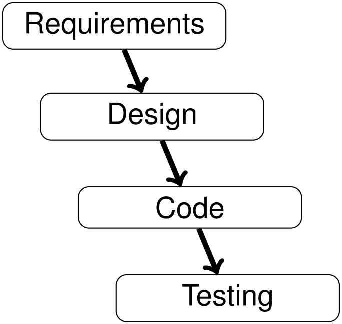
Problem

Information Duplication

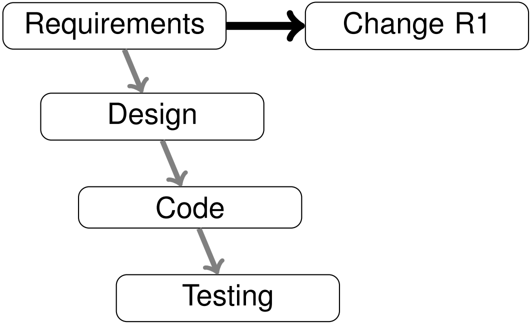


- Wastes resources
- Reduces software quality

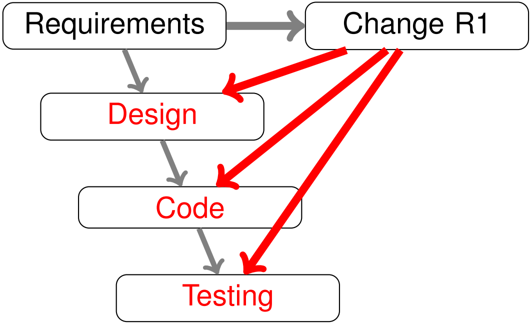
Example



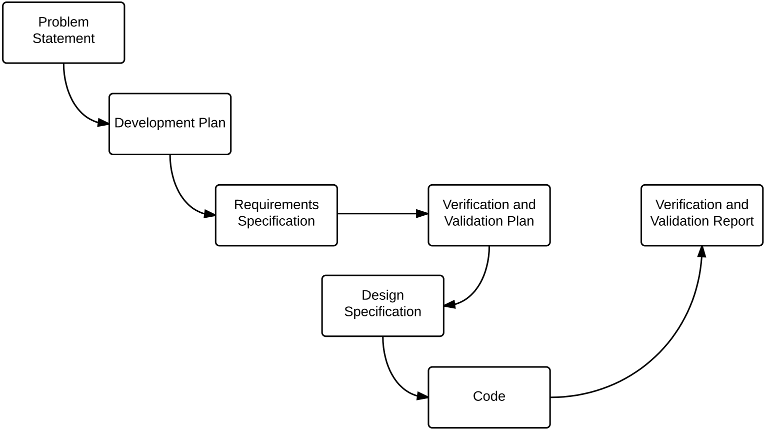
Example



Example



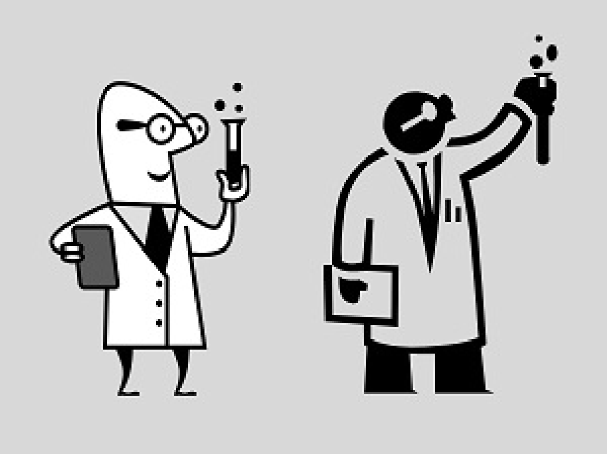
Rational Design Process



Reduced Software Qualities

- Maintainability
- Traceability
- Verifiability
- Reproducibility

Reproducibility



Scope

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Limited to well-understood domains.

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Specifically targeting Scientific Computing (SC)

Scope

Limited to well-understood domains.

Why SC?

- Rich, well-understood background
- SC Developers lack software engineering background

Goals and Objectives

Goals and Objectives

Simplify the development process for SC developers

- Create better software artifacts
- Lower the long term cost of updating/maintaining software
- Improve reproducibility

Goals and Objectives

Create a tool to facilitate a knowledge-based approach

- Create better software artifacts
    - Ensure consistency
- Lower the long term cost of updating/maintaining software
    - Automate creation of software artifacts
- Improve reproducibility

Current Problems in SC Software Development

- Emphasis on science [15]
- Process-heavy approaches are unfavourable [4]
- Not enough knowledge reuse
  - Ex. 37 of 52 triangular mesh generators implemented the same triangulation algorithm [26]
- Lack of understanding of software testing [23]
- Limited tool use (especially version control [42])

Literate Programming (LP)

- Shifts focus to explain (to humans) what the computer should do [17]
- Algorithms are broken down into *chunks* [12]
- Chunks are ordered to promote understanding
- Many tools for (or inspired by) LP

Advantages of LP

- Increases understandability
- More consistent documentation and code [35]
- Code is more maintainable [29]
- Code can be automatically incorporated into documentation
- Documentation and code are updated simultaneously

Drawbacks of LP

- Not yet mainstream
- One-source, one document
- Code-centric

Literate Software Development (LSD)

Combination of LP and Box Structures designed to address:

- Specifying interfaces between modules
- Decomposing boxes
- Implementing designs
- Lack of tool support

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LSD's framework *WebBox* addressed the above, but remains primarily code-focused.

Reproducible Research (RR)

Reproduction can be nearly impossible without the original author's help [11] due to undocumented :

- Assumptions
- Modifications
- Hacks

Reproducible Research (RR)

Compendia [9] provide a means of encapsulating:

- Research reports
- Data
- Code
- ...

Compendia are intended for use in peer review.

Approach

Knowledge Based Approach

Knowledge Capture

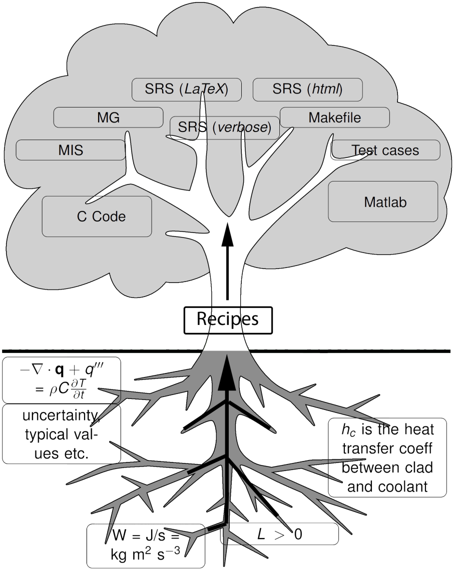
- Expand chunks
- Specification level encapsulation
- Easy to transform

Knowledge Based Approach

Artifact Generation

- Automatically update
- Traceability & maintainability
- Reproducibility

Knowledge Based Approach



Knowledge Based Approach

Artifact Generation

- Automatically update
- Traceability & maintainability
- Reproducibility

Knowledge Based Approach

Drasil Framework

- Practical, example-driven approach
- Small case studies to start
- Larger case studies in progress

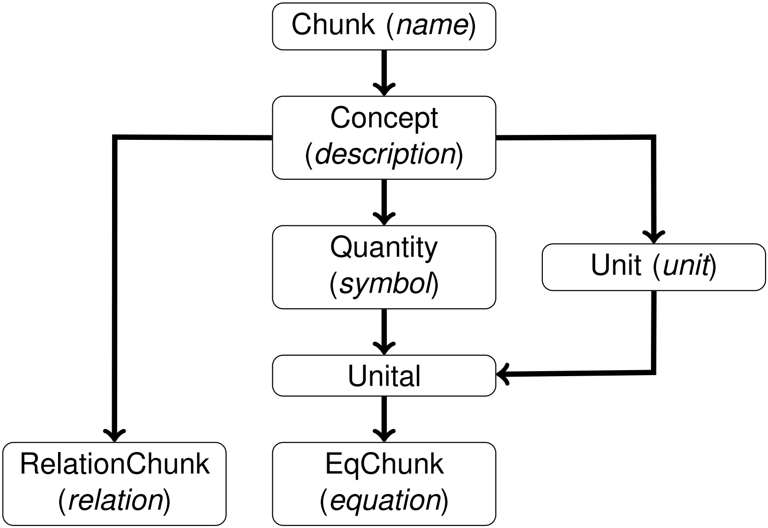
The Drasil Framework

Design

Drasil is currently being implemented as a combination of six eDSLs:

- Expression
- Expression Layout
- Document Layout
- C Representation
- LaTeX Representation
- HTML Representation

Chunks


Chunk (*name*)
Concept (*description*)
Quantity (*symbol*)
Unit (*unit*)
Unital
RelationChunk (*relation*)
EqChunk (*equation*)

Example – Fuel Pin SRS

Original SRS from LaTeX
SRS from Generated LaTeX
Generated HTML SRS

Example – Recipes

```
vars :: [EqChunk]
vars = [h_g, h_c]

s1, s2, s3, s4 :: LayoutObj
s1 = table_of_units si_units
s2 = table_of_symbols vars
s3 = Section 0 (S "Data Definitions") $ map (Definition . Data) vars
s4 = Section 0 (S "Code -- Test") $ map (CodeBlock . toCode CLang Calc) [h_c]

srs :: Quantity s => [s] -> String -> [LayoutObj] -> Document
srs ls author body =
  Document ((S "SRS for ") :+:
    (foldr1 (:+:) (intersperse (S " and ") (map (\x -> U $ x ^. symbol) ls))))
    (S author) body

srsBody :: Document
srsBody = srs vars "Spencer Smith" [s1, s2, s3, s4]
```

Example – Recipes

```
-- Standard code to make a table of units
-- First true example of a (small!) recipe.
module Example.Drasil.Units(table_of_units) where

import Control.Lens ((^.))
import Data.Char (toLower)

import Language.Drasil

table_of_units :: Unit s => [s] -> LayoutObj
table_of_units u = Section 0 (S "Table of Units") [s1_intro, s1_table u]

s1_intro :: LayoutObj
s1_intro = Paragraph
  (S "Throughout this document SI (Syst" :+: (F Grave 'e') :+:
   S "me International d'Unit" :+: (F Acute 'e') :+:
   S "s) is employed as the unit system." :+:
   S " In addition to the basic units, several derived units are" :+:
   S " employed as described below. For each unit, the symbol is" :+:
   S " given followed by a description of the unit with the SI" :+:
   S " name in parentheses.")

s1_table :: Unit s => [s] -> LayoutObj
s1_table u = Table [S "Symbol", S "Description"] (mkTable
  [(\x -> Sy (x ^. unit)),
   (\x -> (x ^. descr) :+: S (" (" ++ map toLower (x ^. name) ++ ")"))
  ] u)
  (S "Table of Units") False
```

Example – Chunks

```
----------------------------------------------------------------
{---------------- Begin tau_c ----------------}
----------------------------------------------------------------
tau_c :: VarChunk
tau_c = makeVC "tau_c" "clad thickness" ((Special Tau_L) `sub` lC)

----------------------------------------------------------------
{---------------- Begin h_c ----------------}
----------------------------------------------------------------
h_c_eq :: Expr
h_c_eq = 2 * (C k_c) * (C h_b) / (2 * (C k_c) + (C tau_c) * (C h_b))

h_c :: EqChunk
h_c = fromEqn "h_c" (S
  "convective heat transfer coefficient between clad and coolant")
  (lH `sub` lC) heat_transfer h_c_eq

------------------------------------------------------------------
-- {---------------- Begin h_g ----------------}
------------------------------------------------------------------
h_g_eq :: Expr
h_g_eq = (2*(C k_c)*(C h_p)) / (2*(C k_c)+((C tau_c)*(C h_p)))

h_g :: EqChunk
h_g = fromEqn "h_g" (S
  "effective heat transfer coefficient between clad and fuel surface")
  (lH `sub` lG) heat_transfer h_g_eq
```

Example – Common Knowledge

```
metre, second, kelvin, mole, kilogram, ampere, candela :: FundUnit
metre    = fund "Metre"    "length (metre)"                "m"
second   = fund "Second"   "time (second)"                 "s"
kelvin   = fund "Kelvin"   "temperature (kelvin)"          "K"
mole     = fund "Mole"     "amount of substance (mole)"    "mol"
kilogram = fund "Kilogram" "mass (kilogram)"               "kg"
ampere   = fund "Ampere"   "electric current (ampere)"     "A"
candela  = fund "Candela"  "luminous intensity (candela)"  "cd"
```

Impressions

Advantages to a knowledge-based approach using Drasil:

1. No inconsistencies inter-/intra-artifact
2. Full traceability
3. Automatic update propagation
4. Reusable knowledge
5. Pervasive bugs

Impressions

Disadvantages:

1. No local hacks
2. Creating common knowledge is difficult
3. Large short-term investment

Next Steps

Planned features:

- More types of information (i.e. physical constraints & reasonable values)
- Generate test cases from constraints
- More output languages (MATLAB)
- More artifact types
- Different document views
- External syntax

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