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Research

Prototyp

Example

Next Step

Literate Development of Families of Mathematical Models

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Next Step

Overview

- 1 Introduction
- 2 Research Plan
- 3 The Prototype System
- 4 Example
- 6 Next Steps

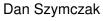


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Introduction Research

Research Prototype Example

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Who am I?



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Introduction

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Education History

- Ph.D. Software Engineering
 - Currently in progress. Started Autumn 2014.
- M.A.Sc. Software Engineering
 - McMaster University 2014
 - Thesis Generating Learning Algorithms: Hidden Markov Models as a Case Study
- B.Eng Software (Game Design)
 - McMaster University 2011



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Introduction

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Current Program Progress

- Completed 3/4 necessary graduate courses
- · Completed part one of comprehensive exam
- Research and prototype system development are underway



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Next Step

Research Key Problem(s)

How can we

- improve the reuse of mathematical knowledge?
- handle knowledge duplication across software artifacts?
- improve the qualities of traceability, maintainability, verifiability and (re)usability?



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Research Musings

How can we improve the reuse of mathematical knowledge?

- Simplify the knowledge store
- Create a means of obtaining knowledge relevant to a project
- Make it accessible



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Research Musings Cont'd

Why is the duplication problem not solved yet?

- Existing tools and abstraction features only go so far
- Knowledge is shared across languages/artifacts/views
- No standard method for encoding knowledge or reusing it



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Next Step

Research Musings Cont'd

Are these problems specific to math software?

No



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Research Solution Plan

- Focus: avoid knowledge duplication across artifacts through reuse
- Maintain: clear traceability between artifacts
- Utilize: generative programming to create artifacts from captured knowledge
- Expand: ideas from literate programming



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Research Solution Plan Cont'd

- Create: a domain-specific language for both knowledge capture & the artifact generator
- Implement: a feature for creating program families
- Test: apply the tool to real world problems in scientific computing



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Prototype Design and Development

- Taking a practical approach
- Focusing on knowledge reuse, as opposed to the formal capture of the knowledge itself



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Prototype How?

A practical approach

- Use existing artifacts as knowledge sources
- Motivated by concrete examples
- Avoid overdesigning and underdeveloping



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Example

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Example: h_g A simple example taken from the SRS for FP

 h_g is a symbol which appears in several locations including:

- The Software Requirements Specification (SRS)
- The Literate Programmer's Manual (LPM)
- The Source Code

Let's take a look!



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Example

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Example: h_g SRS Definition for h_g (original)

Number	DD1
Label	h_g
Units	$ML^{0}t^{-3}T^{-1}$
SI	$\frac{kW}{m^2(^{\circ}C)}$
Equation	$h_g = \frac{2k_c h_p}{2k_c + \tau_c h_p}$
Description	h_g is the gap conductance $ au_c$ is the clad thickness h_p is initial gap film conductance k_c is the clad conductivity NOTE: Equation taken from the code
Sources	source code



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Example

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Example: h_g LPM Definition for h_g (original)

$$h_g = \frac{2k_c h_p}{2k_c + \tau_c h_p} \tag{1}$$

The corresponding C code is given by:

```
double calc_hg(double k_c,double h_b,double tau_c) { return (2*(k_c)*(h_p)) / ((2*(k_c)) + (tau_c*(h_p))); }
```



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Example

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Example: h_g A simple example taken from the SRS for FP

Modifying h_g to reflect changes in requirements is not simple. It involves the following steps:

- Update the definition in the SRS, LPM, etc.
- Modify the source code
- Trace all dependencies
- Modify dependents
- Ensure each artifact is now up to date and consistent



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Example: h_g Simplifying the process

Here is an example of a "chunk" for h_g :

```
{-----}
h g :: Chunk
h g = newChunk $
  [(Symbol, S "h" :-: S "g"),
  (Equation, E h g eq),
  (SIU, S "($\\mathrm{\\frac{kW}{m^2C}}$)"),
  (Description, S
   "effective heat transfer coefficient between clad and fuel surface")
h g dep :: Dependency
h g dep = get dep h g eq
h g eq :: Expr
h g eq = ((Int 2):*(C k c):*(C h p)) :/ ((Int 2):*(C k c):+((C tau c):*(C h p)))
```



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Example: h_g How do we generate?

What do we do with the "chunk"? That depends on the "recipe"!

To create our SRS we use the following recipe:

```
createSRS :: Doc
createSRS = spre $$ doctitle $$
author auth $$ srsComms $$
begin $$ srsBody $$ end
```

To create our LPM we use the following recipe:

```
createLPM :: Doc
createLPM = lpre $$ doctitle $$
    author auth $$ lpmComms $$
    begin $$ lpmBody $$ endL
```



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Example: h_g Generated SRS Output

Number	DD2
Label	h_g
Units	$ML^{0}t^{-3}T^{-1}$
SI	$\frac{kW}{m^2{}^{\circ}C}$
Equation	$h_g = \frac{2k_c h_p}{2k_c + \tau_c h_p}$
Description	h_g is the effective heat transfer coefficient between clad and fuel surface k_c is the clad conductivity h_p is the initial gap film conductance τ_c is the clad thickness NOTE: Equation taken from the code
Sources	source code



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Example: h_g Generated LPM Output

$$h_g = \frac{2k_c h_p}{2k_c + \tau_c h_p} \tag{2}$$

The corresponding C code is given by:

```
double calc_h_g(double k_c, double h_p, double tau_c) { return 2*k_c*h_p/(2*k_c+tau_c*h_p); }
```



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Introduction

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Next Steps

Next Steps

The next 12 months

What next?

- Comprehensive examination part two
- Complete final graduate level course
 - Looking for a category theory course, but open to suggestions
- Complete paper for SPLASH conference
- Complete SEHPCCSE conference paper
- Complete default "recipe" for each software artifact
- Have at least on large example working from the prototype
- Create the external language for using the prototype
- Communicate with industry regarding prototype and example(s)