

**Marcus Denker**

Universität Bern

# Roadmap

- > Research
- > Teaching and Advising Students
- > Open Source Involvement
- > Future

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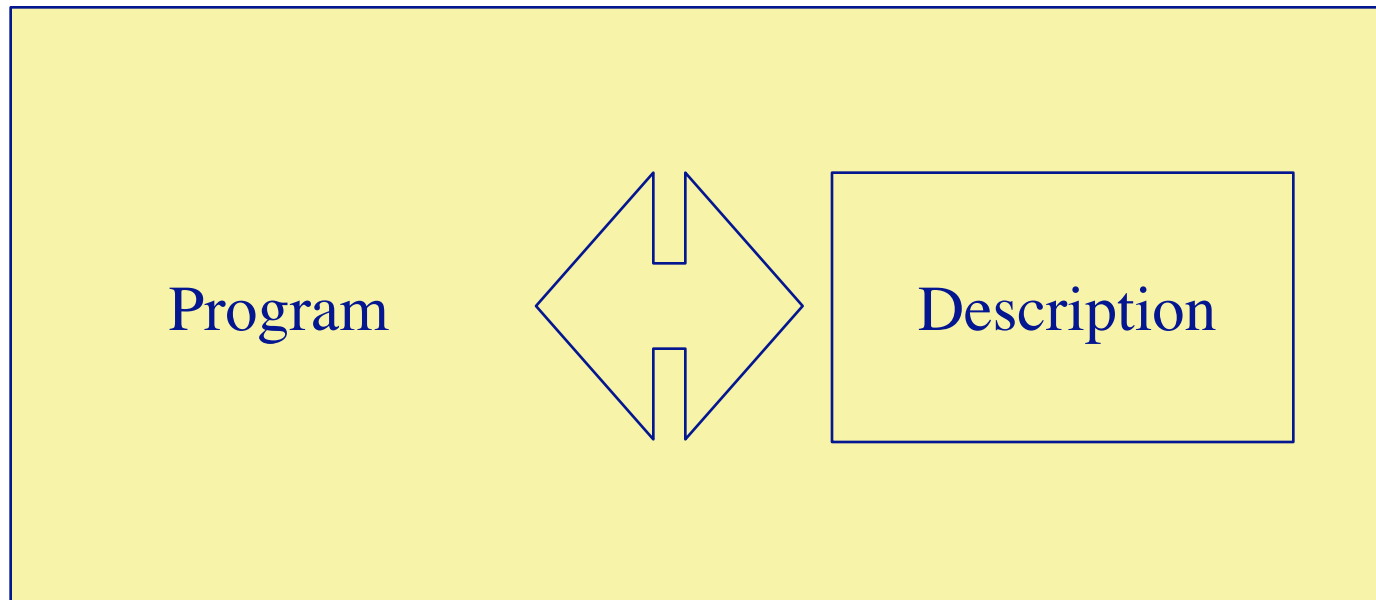
# The Systems of the Future...

- > ... are getting larger and more complex
- > ... are getting more and more dependent on each other
- > ... thus are working in a changing environment

# Three Research Directions

- > Reflective System
- > Context Oriented Programming
- > Virtual Machines

# 1. Reflective Systems



**Query and Change**

# Sub-Method Reflection

- > Method are Objects
  - e.g in Smalltalk
  
- > No high-level model for sub-method elements
  - Message sends
  - Assignments
  - Variable access
  
- > Structural reflection stops at the granularity of methods

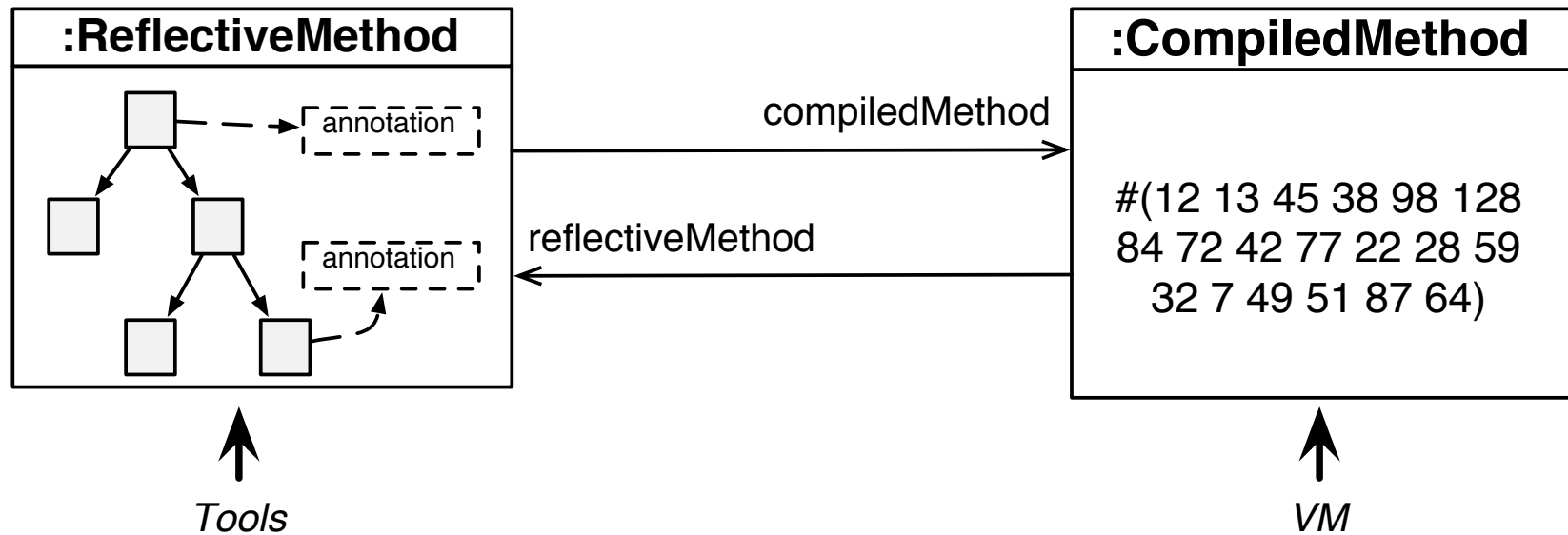
# Sub-Method Reflection

- > Many tools work on sub method level
  - Profiler, Refactoring Tool, Debugger, Type Checker
- > Communication between tools needed
  - Example: Code coverage
- > All tools use different representations
  - Tools are harder to build
  - Communication not possible



# Solution: Reflective Methods

- > Annotated, persistent AST
- > Bytecode generated on demand and cached



# Implementation: Persephone

- > Implementation of Reflective Methods for Squeak
- > Smalltalk compiler generates *Reflective Methods*
  - Translated to bytecode on demand
- > Open Compiler: Plugins
  - Called before code generation
  - Transform a copy of the AST

Marcus Denker, Stéphane Ducasse, Adrian Lienhard  
Philippe Marschall: **Sub-Method Reflection**  
Journal of Object Technology, vol. 6, no. 9,

# Example: Pluggable Type-System

- > Example for textual annotations

```
bitFromBoolean: aBoolean <:type: Boolean :=  
^ (aBoolean ifTrue: [1] ifFalse: [0]) <:type: Integer :=
```

- > Optional, pluggable type-system

- > Types stored as annotations in the Reflective Methods

Niklaus Haldiman, Marcus Denker, Oscar Nierstrasz:  
“**Practical, Pluggable Types for a Dynamic Language,**”  
(Journal of Computer Languages, Systems and Structures, 2009)

# Example: Partial Behavioral Reflection

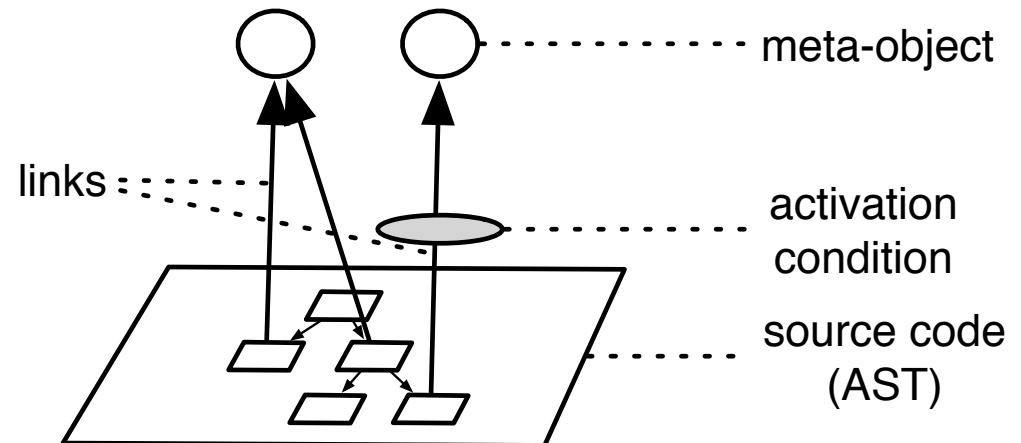
- > Joined Project with University of Chile
- > Realized Reflex for a dynamic languages
- > Support unanticipated use.

Marcus Denker, Stéphane Ducasse and Éric Tanter:  
**“Runtime Bytecode Transformation for Smalltalk”**  
(Journal of Computer Languages, Systems and Structures, 2006)

David Röthlisberger, Marcus Denker and Éric Tanter:  
**“Unanticipated Partial Behavioral Reflection: Adapting Applications at Runtime”**  
(Journal of Computer Languages, Systems and Structures, 2008)

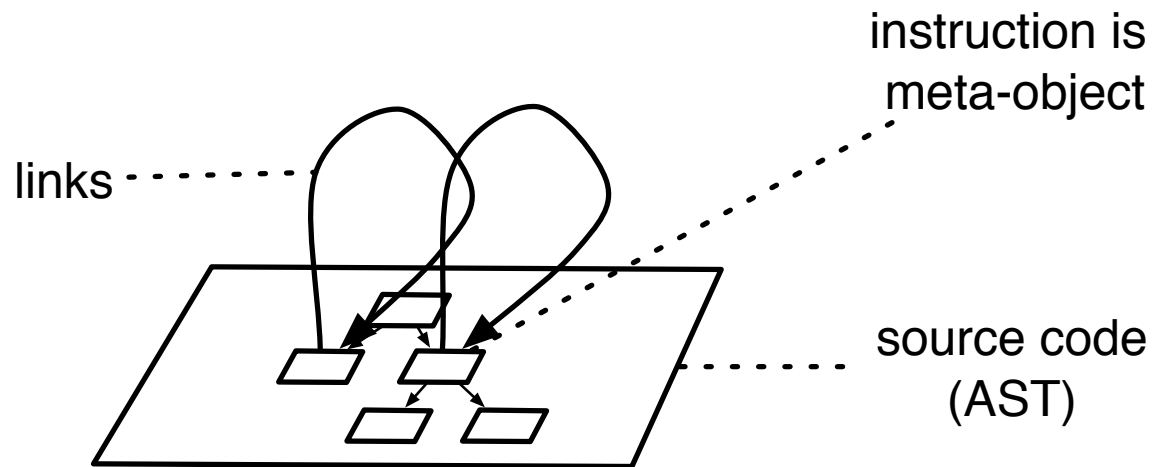
# Using Sub-method Structure

- > Realized Reflex model on top of sub-method reflection
- > Very good performance



# Feature Annotations

- > Features modeled as traces
- > Many Problems
  - Space
  - Merging Traces
- > Solution: annotate structure



Marcus Denker, Orla Greevy, Oscar Nierstrasz:  
**Supporting Feature Analysis with Runtime Annotations** (PCODA 2007)

## 2. Context Oriented Programming

- > Software needs to work in changing environments
- > Code to deal with context specific behavior spread all over the system
- > No representation of context

Martin von Löwis, Marcus Denker and Oscar Nierstrasz:  
**Context-Oriented Programming: Beyond Layers**  
(ICDL 2007)

# Context-Aware Aspects

- > Aspects: modularizing crosscutting concerns
- > Context code crosscuts application code

Éric Tanter, Kris Gybels, Marcus Denker and Alexandre Bergel:  
**“Context-Aware Aspects”**  
(Software Composition (SC 2006), LNCS, vol. 4089)



# ChangeBoxes

- > Programming Languages do not model change
- > Changeboxes:
  - All changes to code are recorded
  - Execution of old versions

Marcus Denker, Tudor Gîrba, Adrian Lienhard, Oscar Nierstrasz,  
Lukas Renggli and Pascal Zumkehr:  
**“Encapsulating and Exploiting Change with Changeboxes”**  
(ICDL 2007)

# MetaContext

- > Problem: applying behavioral reflection on system classes (Numbers, Array...).
- > Reason: meta-object call recursion
- > Solution: meta-execution context

Marcus Denker, Mathieu Suen and Stéphane Ducasse:  
**“The Meta in Meta-object Architectures”**  
(Proceedings of TOOLS EUROPE 2008, LNBIP, vol. 11)

## 3. Virtual Machines

- > Late-bind compilation for dynamic languages
- > Provide virtual, easy to change “hardware”

# Squeak J3

- > Just-In-Time Compiler for Squeak Smalltalk
- > Ported from PowerPC to Intel
  - 2000/2001 while at Disney

Marcus Denker:  
**Entwurf von Optimierungen für Squeak**  
(Studienarbeit, University of Karlsruhe, 2002)

# Bytecode-to-Bytecode optimization

- > Virtual Machines are very complex
  - Especially dynamic Optimizers
- > Idea: Move optimization out of the VM
- > AOSTA: Eliot Miranda, 2002/2003
- > My Master's Thesis, 2004
  - Prototype for Squeak.

Marcus Denker:

**Erweiterung eines statischen Übersetzers zu einem Laufzeitübersetzungssystem**

(Masters thesis, University of Karlsruhe, 2004)

# Interpreter Inline Caches

- > Bring some ideas of high-performance JIT Compilers back to simple Interpreters
- > Interesting for Bytecode-to-Bytecode optimization

Michael Haupt, Robert Hirschfeld and Marcus Denker:  
**Type feedback for bytecode interpreters**  
(ICOOOLPS'2007)

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# Students

- > 5 Master Projects, 1 Bachelor co-advised
  - Students contributed to research
  - 4 published as papers at conferences
  - 2 later extended to Journals
  
- > Google Summer of Code



# Courses and Lectures

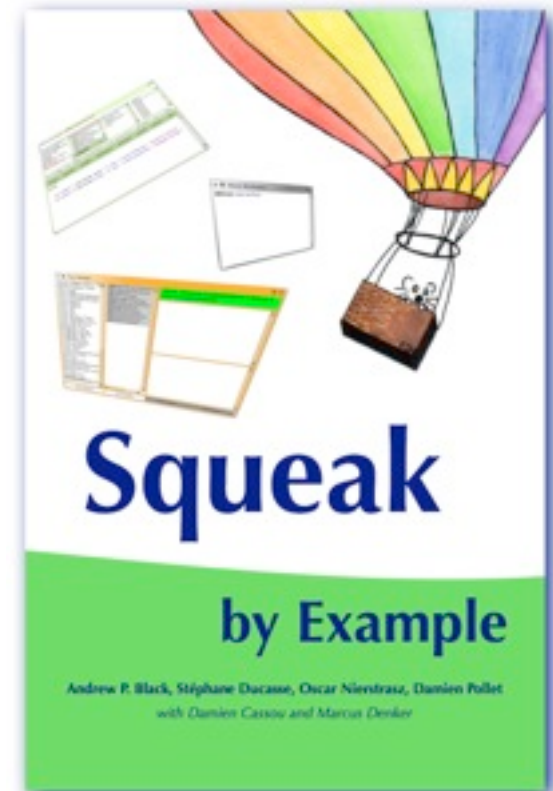
- > Assistant
  - Dynamic Object-Oriented Programming with Smalltalk (2006, 2007)
  - Smalltalk (2004). (Prof. Stephane Ducasse)
  
- > Lectures given as part of courses:
  - HPI Germany
  - Bern
  - University of Chile
  
- > Current: Compiler Construction, University Bern
  - Two Lectures on SSA and Optimizations

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# Squeak

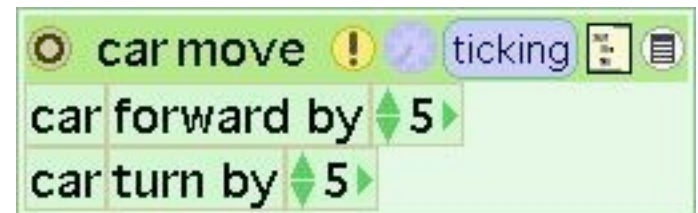
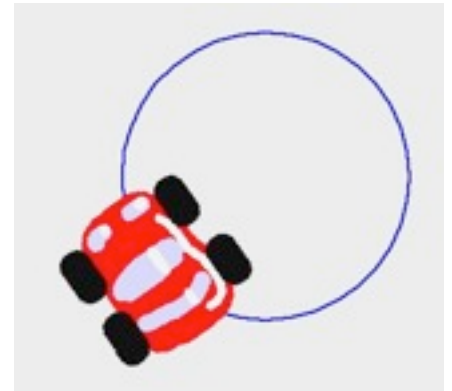
- > Open Source Smalltalk System
  - Alan Kay, Dan Ingalls
- > Responsible for Version 3.9
- > Co-Founder Squeak Foundation
  - Board Member till 2007



60.000 Downloads

# eToys

- > Programming for Children
- > On the OLPC (\$100 Laptop)
- > Based on Squeak



- Worked with Alan Kay's group on Squeak
- Founder, Squeak Germany e.V.
- Translated Book "Powerful Ideas in the Classroom"

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# Future Research

- > Context and Reflection
- > Bio-Inspired Reflective Languages
- > Compiler for Dynamic Languages

# Context and Reflection

- > Reflection is powerful, but dangerous.
- > How can we control reflective structural change?
- > Continue work started with ChangeBoxes and MetaContext

# Runtime Compilers

- > Back to Bytecode-to-Bytecode Optimization
- > SStA: Son-of-AOStA
  - revisit work done on AOStA
- > Research: Integrate with Reflection Framework



# Bio-Inspired Reflective Languages

- > Complex, ever-evolving, dynamic Systems?
  - They are everywhere!
- > Idea: **<CENSORED>** as a concept for reflective languages



# Future Teaching

- > Continue with advising Master and Bachelor Students
  
- > Possible Courses at University of Chile:
  - Programming Languages
  - Software Engineering
  - Compiler Construction
  - Virtual Machines

# Future Open Source

- > Pharo: Squeak, rebooted
  - Professional Development
  - Stable basis for Research
  - INRIA, France
  
- > Squeak by Example, OLPC Edition
  - SBE Focusing on Squeak for OLPC
  - Programming beyond eToys



# Questions?

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