Gen-O-Fix
Embedded Genetic Improvement Programming via Reflection

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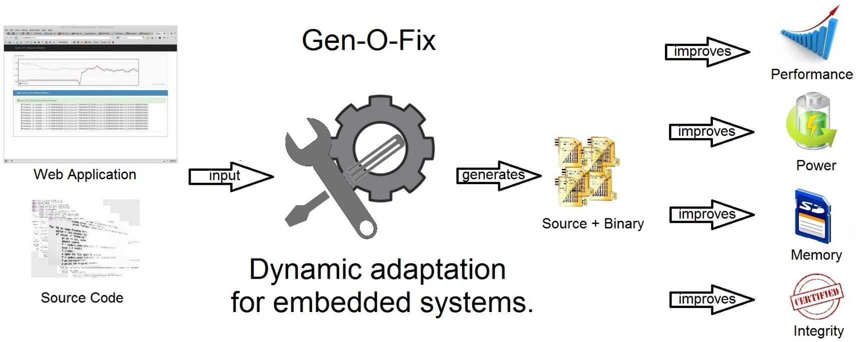
Outline

- **What**: An Embedded Self-Improving System.
- **Why**: Maintanance dominates software lifecycle cost [5] . . .
- **How**: Reflective Genetic Improvement Programming in Scala.

Gen-O-Fix System Diagram



Genetic Improvement Programming (GIP)

GIP can be used to:

- Multi-objective trade-off between non-functional properties [2].
- Fix bugs [5] (maintanance dominates software lifecycle cost).
- Optimize/improve functional properties.

Embedding Adaptivity

From `http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/J017515/1`

> *[DAASE] places computational search at the heart of the processes and products it creates and embeds adaptivity into both.*

Gen-O-Fix is a proof-of-concept of a key part of the DAASE manifesto: creating systems with the facility for embedded self-optimization.

Gen-O-Fix Framework Features

- Operates via the new relection features of the Scala language.
- Source (to Abstract Syntax Tree) to Source + Binary transformation.
- Can be used within ‘always-running’ programs (embedded systems, webservers etc.).

The Scala Programming Language

- Uniquely OO-functional programming hybrid.
- Statically-typed (traps type-errors at compile-time).
- JVM language - fully interoperable with Java (and other JVM languages e.g. Clojure).

Scala In Industry

- Supports expressive webservice frameworks (‘Hello, Web’ in 6 lines of code).
- Increasingly popular for concurrency support (Twitter core rewritten in Scala).

Scala Reflection: Homoiconicity 1

Code as data, data as code.

```
// code to data:
var m = 2; var x = 3; var c = 4
val expr = reify( ( m * x ) + c )
println( "AST = " + showRaw( expr.tree ) )

// output:
AST = Apply(Select(Apply(Select(Select(Ident("m"),
"elem"),"$times"),List(Select(Ident("x")),
"elem"))),"$plus"),List(Select(Ident("c"),"elem")))
```

Scala Reflection: Homoiconicity 2

```
// run AST datatype as code:
println( "eval = " + expr.tree.eval() )

// output:
eval = 10
```

Scala Reflection 3: Rich ASTs and Pattern Matching

Since AST nodes are first class objects in Scala, we have a lot of declarative information available:

- **Well-formedness** of ASTs can be checked by the **type-system**.
- We can use Scala's powerful **pattern matching** facility to operate on specific AST fragments:

```
case Apply( Select( Ident( name : TermName ), t2 :
    TermName ), args )
if t2 == newTermName( "apply" ) =>
// manipulate AST
}
```

- Makes it easier to do context-aware recombination/mutation and other transformations.
- Can help when addressing scalability issues [5].

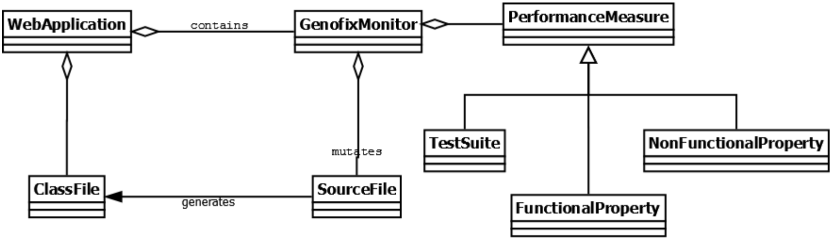
Search Based Software Engineering (SBSE)

- SBSE starts with only two key ingredients [3]:
- The choice of the representation of the problem. *'Software is its own substrate'*.
- The definition of the objective function.

Gen-O-Fix Framework-Level Parameters

- ‘As simple as possible’:
- Client source code: url that points to Scala code file containing signature $I \to O$ (e.g. $Double \to Double$).
- Client functionality fitness: $f : (I \to O) \to \mathbb{R}$.
- Many fitness measures for non-functional properties (e.g. power-consumption) could be supplied ‘as standard’.

UML Class Diagram



A simple proof-of-concept . . .

- A stock-price predictor for shares in David Bowie
- Achieved via univariate symbolic regression . . .
- of a function extracted from the web-application source code.

Summary

- Created a proof of concept: embedded symbolic regression.
- Have started looking at self-repair e.g. Zune and GCD bugs [6].
- Next step: Match more complex AST patterns, more powerful transformation rules.

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