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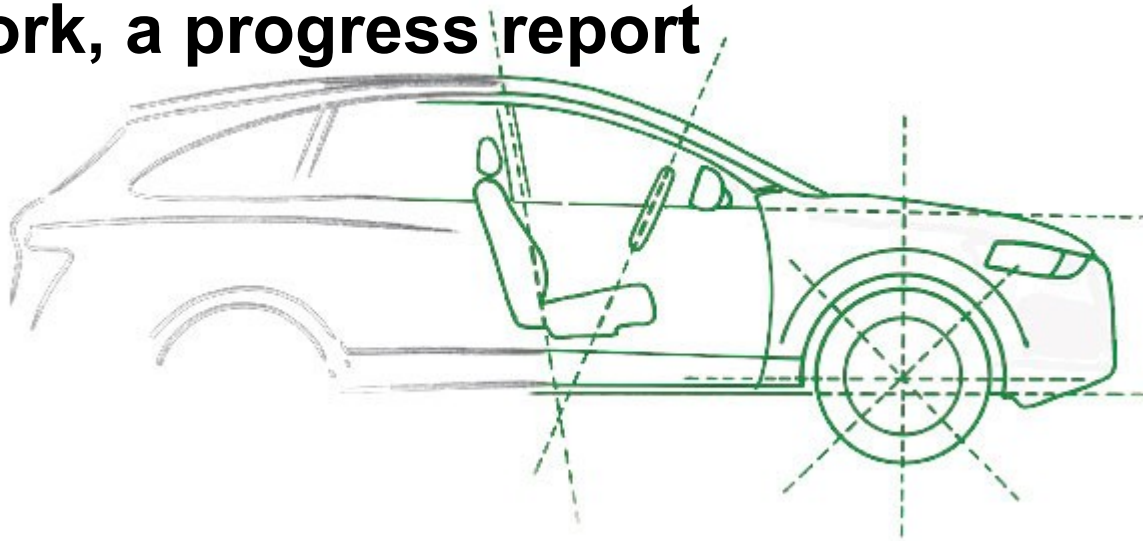
Evolutionary white-box software test with the EvoTest Framework, a progress report



Peter M. Kruse

April 1st, 2009

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Motivation

- Subsystems of today's luxury cars have up to 15 million lines of code
- Test automation needed

- Can Evolutionary Testing be the solution?

  – Some prototypes exists
  – Still mainly research-based

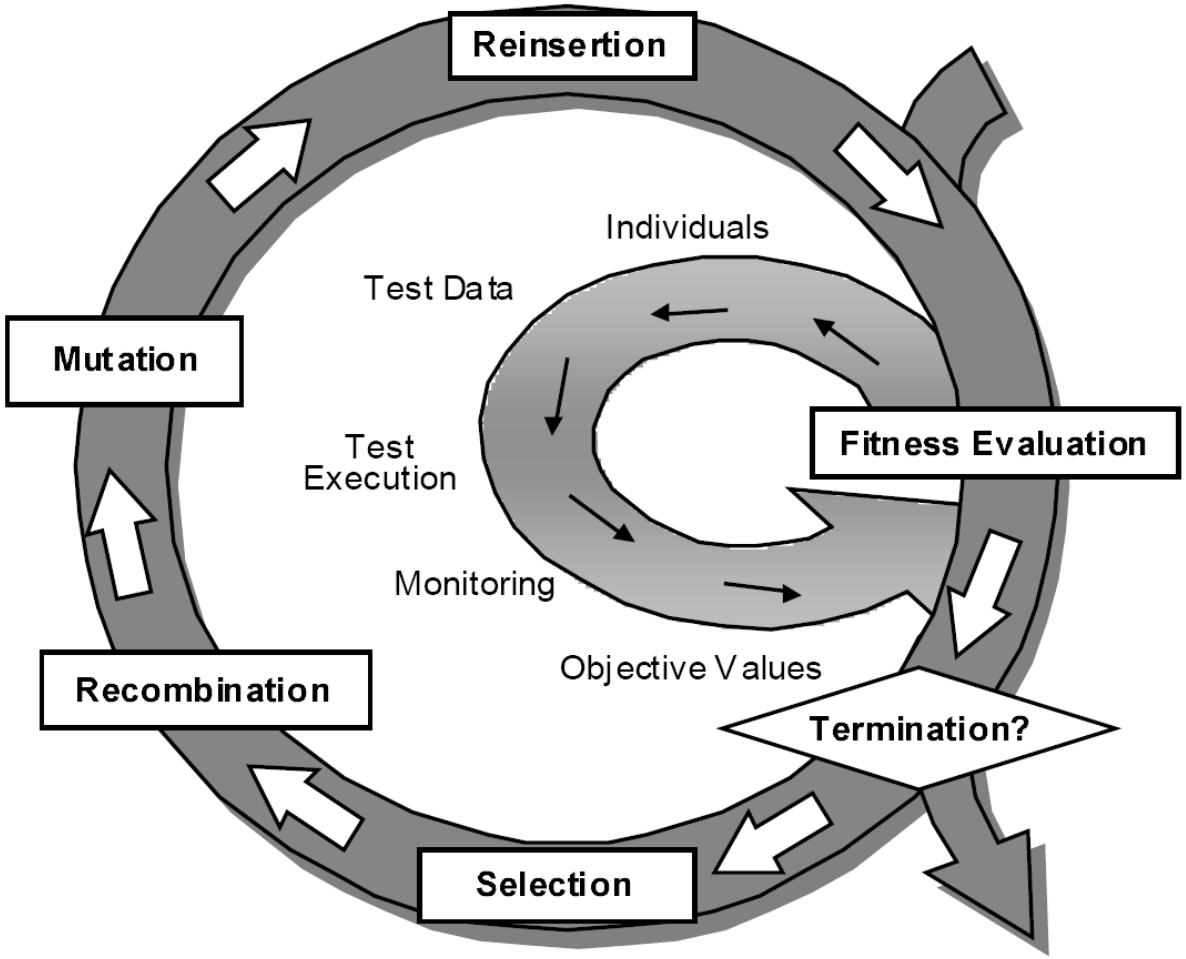
- Why?

White Box Testing / Structural Testing

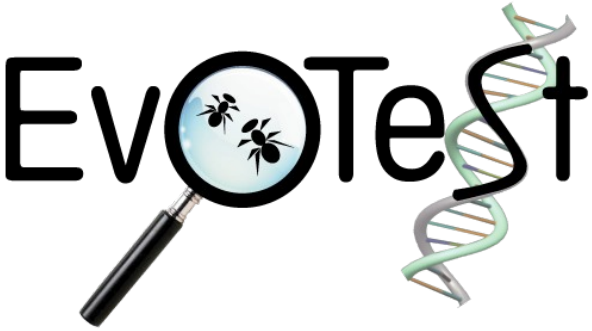
- Aim:
  - Maximal code coverage [1]
  - Little effort as possible
  - Efficient selection of test cases
- Usage:
  - During unit-testing phase of a software project
- Problem:
  - Finding test cases which exercise all branches is a complex task

[1)] As required by ISO 26262, IEC 61508, DO-178B

Evolutionary Structural Testing



EvoTest



- EU funded research project (IST-33472)
- Aim:
  - Find solutions for software testing
  - Using evolutionary adaptive techniques
- EvoTest Framework:
  - Automated structural testing (White Box)
  - Functional testing (Black Box)
  - Signal Generator Component
  - …

http://www.evotest.eu/

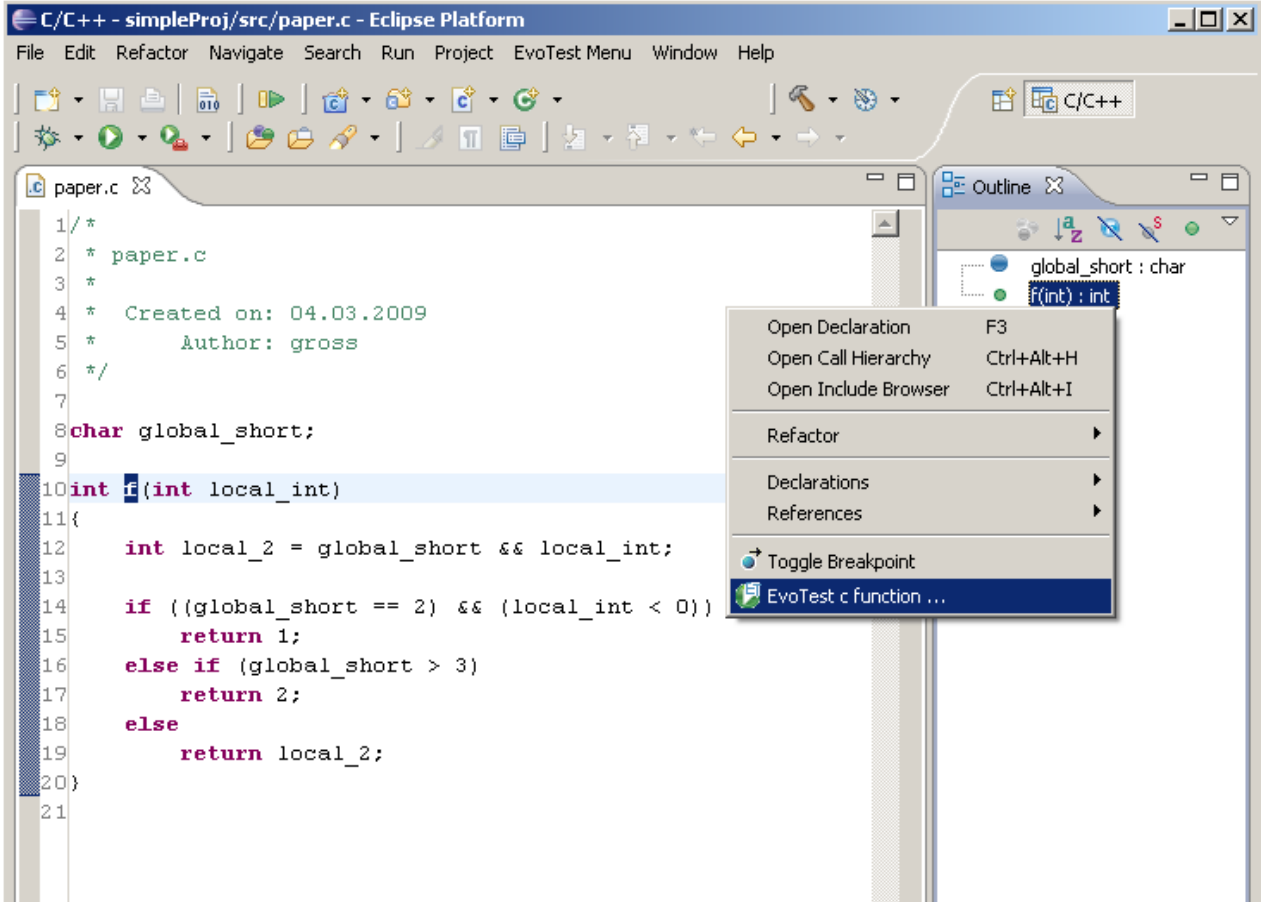
Case Studies

- 4 case studies
- Embedded Software Module
- Automotive Industry
- Implemented in C Language

Case Study	Description
A	Active Brake Assist software module *(dSpace TargetLink)*
B	Adaptive Headlight control software module *(dSpace TargetLink)*
C	Door-Lock control software module *(ETAS ASCET)*
D	Electric window control software module *(ETAS ASCET)*

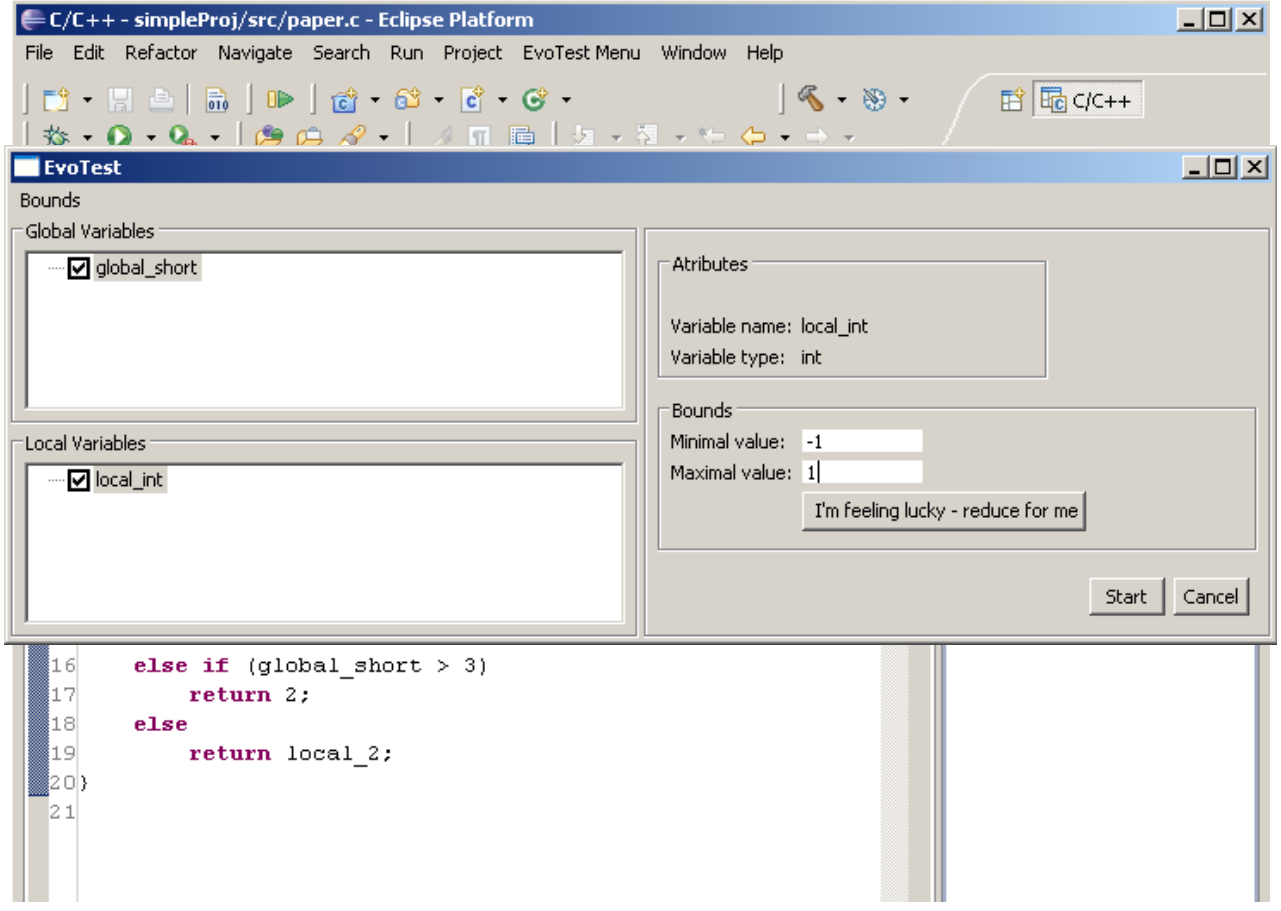
Application

- Integration with Eclipse CDT



Application

- Integration with Eclipse CDT



Application

- Result view

C/C++ - simpleProj/src/paper.c - Eclipse Platform

File Edit Refactor Navigate Search Run Project EvoTest Menu Window Help

paper.c

```
1 /*
2  * paper.c
3  *
4  *  Created on: 04.03.2009
5  *      Author: gross
6  */
7
8 char global_short;
9
10 int f(int local_int)
11 {
12     int local_2 = global_short && local_int;
13
14     if ((global_short == 2) && (local_int < 0))
15         return 1;
16     else if (global_short > 3)
17         return 2;
18     else
19         return local_2;
20 }
21
```

Outline

- global_short : char
- f(int) : int

Application

- Result view

C/C++ - simpleProj/src/paper.c - Eclipse Platform

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paper.c

```c
/*
 * paper.c
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char global_short;

int f(int local_int)
{
    int local_2 = global_short && local_int;

    if ((global_short == 2) && (local_int < 0))
        return 1;
    else if (global_short > 3)
        return 2;
    else
        return local_2;
}
```

```
Covered 6 out of 10 branches: 60%

//Test Case n°1
//global variables:
char global_short = 126;
//parameters
int local_int = 0;

//Test Case n°2
//global variables:
char global_short = -58;
//parameters
int local_int = 0;

//Test Case n°3
//global variables:
char global_short = 69;
//parameters
int local_int = 1;
//end
```

Results

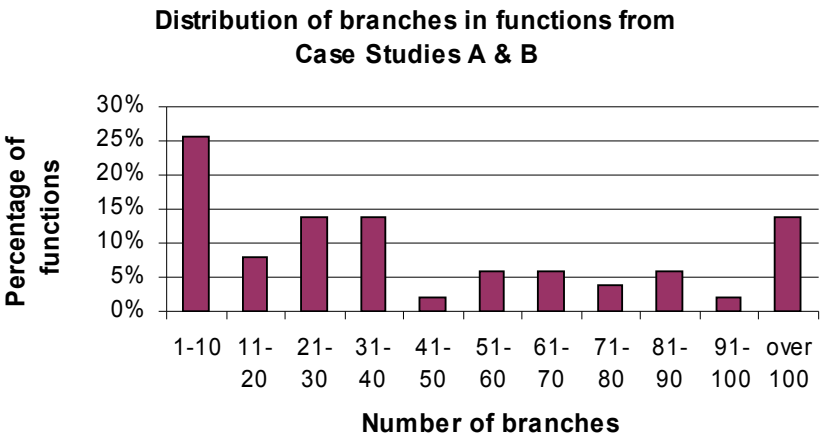
Case Study	Total Functions	Functions containing `if` or `while` statements	Test case generation successful	
A	2	2	1	(1)
B	77	44	34	(48)
C	486	70	30	(50)
D	197	67	3	(27)
All	762	183	68	(126)

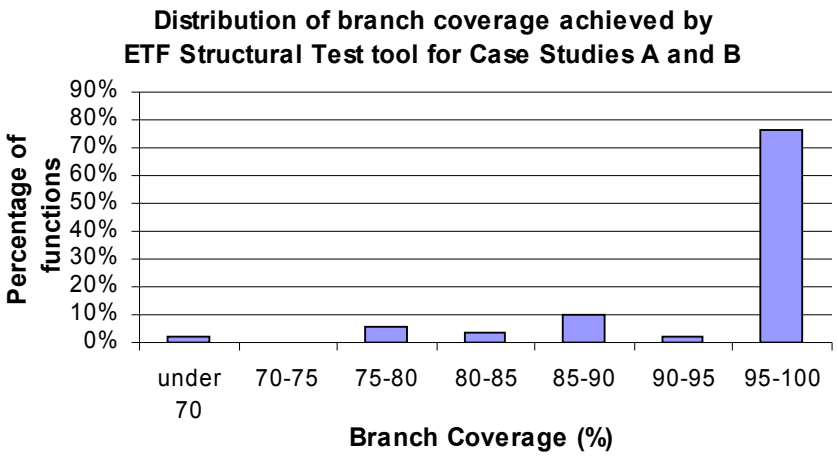
- Coverage
  - 37 % with early version
  - 69 % with later version

Results

Reason for failure to generate test cases	Functions	
Pointer to simple type	62	0
Array operations / Pointer to arrays	43	43
Pointer to void	12	12

Coverage Rates





Way forward

- **Parameter Reduction**
  - Large search space increases duration of test case generation
  - Unnecessary parameters might be of unsupported type
- ➢ Using data-flow analysis, increased coverage of software modules could be achieved

  As described by M. Harmen et al. “The Impact of input domain reduction on search-based data generation”, 2007

- **Support for pointers**
  - Major reason for failure of test-case generation
  - Pointers are too common to not support them
- ➢ Has been established in later version of tool

  Approach described by M. Prutkina & A. Windisch “Evolutionary structural testing of software with pointers”, 2008

Way forward

- **Volatile variables**
  - Variables can be memory-mapped to I/O registers
  - Variable values can change asynchronously to program flow
- ➢ Since the function under test is executed in isolation, changes to volatile variables need to be simulated

- **Multi-Function Instrumentation**
  - Test case generation only for single isolated functions
  - Called functions are not yet instrumented
- ➢ Optimizing the order of evaluation of single functions can lead to a reduction in generated test data for the module as a whole

- **GUI Improvements**

Conclusion

- The tool requires the source code under test to be preprocessed
- Despite the tool still being a prototype, function coverage of 69% was possible
- Significant work is still required before evolutionary structural testing is ready for industrial application
- Nevertheless this promising approach deserves further research

- Thank you

Peter M. Kruse
Berner & Mattner Systemtechnik
peter.kruse@berner-mattner.com