Automating maintenance: the way out of the software renovation paradox

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Large-scale semi-automated migration of legacy C/C++ test code

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Abstract
This is an industrial experience report on a large semi-automated migration of legacy test code in C and C++. The particular migration was enabled by automating most of the maintenance steps. Without automation this particular large-scale migration would not have been conducted, due to the risks involved in manual maintenance (risk of introducing errors, risk of unexpected rework, and loss of productivity). We describe and evaluate the method of automation we used on this real-world case. The benefits were that by automating analysis, we could make sure that we understand all the relevant details for the envisioned maintenance, without having to manually read and check our theories. Furthermore, by automating transformations we could reiterate and improve over complex and large scale source code updates, until they were “just right.” The drawbacks were that, first, we have had to learn new metaprogramming skills. Second, our automation scripts are not readily reusable for other contexts; they were necessarily developed for this ad-hoc maintenance task. Our analysis shows that automated software maintenance as compared to the (hypothetical) manual alternative method seems to be better both in terms of avoiding mistakes and avoiding rework because of such mistakes. It seems that necessary and beneficial source code maintenance need not to be avoided, if software engineers are enabled to create bespoke (and ad-hoc) analysis and transformation tools to support it.

Keywords
parsers, pattern matching, program analysis, refactoring, source code generation.
A case of automated renovation at Philips

Philips high-tech interventional X-ray system for the diagnosis and treatment of cardiovascular diseases.

5,840 surgical source code changes in millions
1 line Rascal per 40 lines of C++ changed
1 ad-hoc parser for CMake files
patching “unpreprocessed” code
generated batch scripts for running tests and committing changes

1 programmer
millions of lines of C++ code
move from own test library to google test library
Software Maintenance

“changing source code after the initial release”

**Engineering**

- **Design** stage
  - System architecture is *designed*
  - Reversible design decisions
  - Short term successes
  - Testing is easy

- **Growth** stage
  - Incremental additions and corrections *grow*
  - Misconceptions and haste lead to design erosion
  - Co-evolution: changes become scattered
  - “Accidental” code, when it works -> commit
  - Testing becomes cumbersome

- **Stagnation** stage
  - Changes break the system; increasing focus on analysis
  - Working on bugs rather than features
  - “How did this ever work”?
  - Critical reading pushes out (creative) writing

**Business**

- Early **Benefits** of software ownership
  - Tactical advantage: fast time-to-market
  - Short horizons
  - Incremental costs

- ROI, growing **Cost** of software ownership
  - Lower margins over time
  - Increasing maintenance costs
  - Cost of replacement out-weighs the ROI

- Inevitable **Risks** of software ownership
  - Software becomes cause of stagnation
  - Employee turn-over rate too high
  - Cost of maintenance outweighs total value
The cost of success

- **Yearly cost**
- **Time**
  - 2-5y
  - 5-10y
  - 10-40y

**Design**
- Benefits

**Growth**
- ROI and rising costs

**Stagnation**
- Increased risk
- End
- Out of business
Maintaining Code: **Necessary** and Challenging

- certif GDPR compliance
- add WWW interface
- add live user feedback
- fix performance bottleneck for peak user loads
- upgrade to Windows 10 from Windows 95
- scale to \(\{\text{giga,tera,peta}\} \text{byte/s} \) throughput
- integrate 3D simulation
- add live user feedback
- merge this acquired software "stack" into our own, with backward compatibility
- switch to ARM
- Port to Linux
Not maintaining code: recipe for stagnation

- Loss of market potential (no innovation)
- Loss of strategic economic benefits (no flexibility)
- Loss of expertise (people move elsewhere)
Maintenance Paradox

**Never** change a working component

- leads to more growth and technical debt
- leads to more instability

**Always** adapt to changing circumstances

- no time for new bugs
- have to align to new tech and new business
A way out: Rascal

- **Reuse** parsers, name/type analysis, pattern matching, tree traversal, relational queries, origin tracking, …

- **Script** “little” maintenance tasks in Rascal
  - High-level programming (meta-programming)
  - Automate the repetitive/boring parts
  - Avoid “inhumane” manual code analysis and transformation
  - Motivating for the maintenance experts!
Rascal is a “language parametric” DSL for meta programming.

We use Rascal for all kinds of analysis and design tasks: model-to-code, model-to-model, code-to-model, code-to-code, verification, static analysis, visualisation, model checking, and on all kinds of languages (programming, modelling, data, visual, textual).
Open-source Community


- **Academic/Educational**: Centrum Wiskunde & Informatica, Universiteit van Amsterdam, Vrije Universiteit, Hogeschool van Amsterdam, Open Universiteit, TU Eindhoven, Rijksuniversiteit Groningen, East Carolina University, Bergen University, and many more

- Empirical study of software projects; software evolution, reverse engineering

- Design and implementation of Domain Specific (Modeling) languages

- **Industrial collaborations**: SIG, Philips, ING Nederland, Canon

  - Automated code maintenance, Reverse Engineering

  - Domein Specific Languages and Model Driven Engineering

- **Online**: 406 stackoverflow questions, 317 github stars, 25 developers

- 100% Rascal shop: SWAT.engineering BV
Existing Front-ends

- Java code, JVM bytecode
- C/C++ code ("Clair" Rodin Aarssen)
- Lua source code
- PHP source code
- Python source code
- Javascript source code
- Ada source code <under development> (ESI)
- XML
- JSON

- CSV
- JDBC
- .NET assemblies
- C# source code
- Jupyter Notebooks
- Halide C++ syntax
- Oberon: full compiler
- … context-free grammars for building your own front-end …
Lessons learned

- Rascal enables easy maintenance scripting
- Existing Philips regression tests are very important
- C/C++ preprocessor problems can be avoided
- Always more kinds input files then expected (CMake)
- AST origin tracking of Rascal is a key enabler
- More in the paper :-)

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Take aways

1. Short-term vs long-term priorities clash in software maintenance
2. Automating maintenance with Rascal is a way out
3. Scripting maintenance is a motivating task (think retention!)

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