

Rachel

Repairing Automata for Choreographies by Editing Labels
<http://service-technology.org/rachel>

Version 1.14, 18 January 2010

Niels Lohmann

About this document:

This manual is for Rachel, version 1.14, a tool to repair automata for choreographies by editing labels, last updated 18 January 2010.

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1 What is Rachel?

Rachel is a tool to repair deadlocking service choreographies. Much work has been conducted to analyze service choreographies to assert manifold correctness criteria. While errors can be detected automatically, the *correction* of defective services is usually done manually. Rachel implements a graph-based approach to calculate the minimal edit distance between a given defective service and synthesized correct services. This edit distance helps to automatically fix found errors while keeping the rest of the service untouched.

For more information, see the following publications or links:

- Niels Lohmann. **Fixing Deadlocking Service Choreographies Using a Simulation-based Graph Edit Distance**. In Monika Solanki, Barry Norton, and Stephan Reiff-Marganiec, editors, *3rd Young Researchers Workshop on Service Oriented Computing, YR-SOC 2008, London, UK, 12–13 June 2008, Proceedings*, pages 13–20, June 2008.

This paper briefly describes the setting in which Rachel can be used as well as first experimental results. The paper is part of the distribution of Rachel (`doc/background.pdf`) and is freely available at http://www.teo.informatik.uni-rostock.de/ls_tpp/publications/Lohmann_2008_yrsoc.pdf. Furthermore, slides of the talk are available at http://service-technology.org/wiki/publications/lohmann_2008_yrsoc.

- Niels Lohmann. **Correcting Deadlocking Service Choreographies Using a Simulation-Based Graph Edit Distance**. In Marlon Dumas, Manfred Reichert, and Ming-Chien Shan, editors, *Business Process Management, 6th International Conference, BPM 2008, Milan, Italy, September 1–4, 2008, Proceedings*, volume 5240 of *Lecture Notes in Computer Science*, pages 132–147. Springer-Verlag, September 2008.

This paper (a preprint is available at http://www.teo.informatik.uni-rostock.de/ls_tpp/publications/Lohmann_2008_bpm.pdf) gives all definitions and details on the algorithms implemented in Rachel. In addition, a case study is described and runtimes of Rachel are examined. This case study is part of the distribution of Rachel (`exp/bpm2008.tar.gz`) and can be executed with `make experiments`.

2 First Steps

2.1 Setup and Installation

1. Go to <http://service-technology.org/files/rachel> and download the latest release version of Rachel, say ‘`rachel-1.14.tar.gz`’. To setup and compile Rachel, change into your download directory and type

```
tar xfz rachel-1.14.tar.gz
cd rachel-1.14
./configure
make
```

After compilation, a binary ‘`src/rachel`’ is generated.¹ If you experience any compiler warnings, don’t panic: Rachel contains some generated or third party code that we cannot influence.

2. To test whether everything went fine, type

```
make check
```

to execute the testcases located in ‘`tests`’. If everything went fine, you should see something like:

```
=====
All 16 tests behaved as expected (5 expected failures)
=====
```

If an error occurs, please send the output to rachel@service-technology.org.

3. To install the binary, the manpage, and the documentation, type

```
make install
```

You might need superuser permissions to do so.

If you need any further information, see file ‘`INSTALL`’ for detailed instructions.

2.2 Contents of the Distribution

The distribution contains several directories:

- ‘`doc`’ The Texinfo documentation of Rachel and a PDF file ‘`background.pdf`’ with a short description of the setting in which Rachel should be used. The documentation can be created using ‘`make pdf`’. Note you need to have Rachel properly installed before (see Installation description above).
- ‘`exp`’ Experiments and case studies published in several papers. For each file, say ‘`bpm2008.tar.gz`’, a Makefile target ‘`bpm2008`’ exists. You can run all experiments with ‘`make experiments`’.
- ‘`man`’ The manpage of Rachel which can be displayed using ‘`man rachel`’ after having Rachel installed (see Installation description above).
- ‘`maintainer`’ Some scripts for maintainers of Rachel which can be used to create and distribute releases.

¹ On Microsoft Windows, the file will be called ‘`rachel.exe`’.

- 'src' The source code of Rachel.
- 'tests' Testcases for Rachel which check the generated binary. The testscripts check the command line options, file input and output, simulation calculation, and matching calculation.

3 Invoking Rachel

Rachel is a command line tool and does not come with a fancy GUI. However, Rachel can be easily scripted and combined with other tools.

3.1 Command Line Options

For an overview of the command line options, type ‘`rachel -h`’ to see the following help screen:

```
rachel 1.14

Rachel: Repairing Automata for Choreographies by Editing Labels

Usage: rachel [-h|--help] [--detailed-help] [--full-help] [-V|--version]
        [-mMODE|--mode=MODE] [-v|--verbose] [-aFILE|--automaton=FILE]
        [-oFILE|--og=FILE] [-dFILE|--dot=FILE] [--png]
        [--node-similarity=DOUBLE] [--discount=DOUBLE] [--benefit-keep=DOUBLE]
        [--benefit-change=DOUBLE] [--benefit-insert=DOUBLE]
        [--benefit-delete=DOUBLE] [-tDOUBLE|--threshold=DOUBLE]
        [-cFILE|--conf-file=FILE] [--noClean]

About Rachel:

  -h, --help                Print help and exit
  --detailed-help          Print help, including all details and hidden
                           options, and exit
  --full-help              Print help, including hidden options, and exit
  -V, --version            Print version and exit

Options:
  -m, --mode=MODE          Execution mode of Rachel (possible
                           values="matching", "simulation", "og",
                           "sa" default='matching')
  -v, --verbose            Verbose output: mostly status information
                           during longer calculations. (default=off)

File input:
  -a, --automaton=FILE     Read a service automaton. Any annotated
                           formulae are ignored.
  -o, --og=FILE           Read an operating guideline

File output:
  -d, --dot[=FILE]        Create a Dot file. If no filename is given, it
                           is derived from the input filename(s).
  --png                   Together with option "dot", also a PNG image
                           is created if Graphviz Dot was found by the
                           configure script. (default=off)

Configuration of used cost function:
  --node-similarity=DOUBLE Node similarity (default='1.0')
  --discount=DOUBLE        Discount factor (default='0.5')
  --benefit-keep=DOUBLE    Benefit of label keeping (default='1.0')
  --benefit-change=DOUBLE  Benefit of label change (default='0.7')
  --benefit-insert=DOUBLE  Benefit of label insertion (default='0.2')
  --benefit-delete=DOUBLE  Benefit of label deletion (default='0.2')
  -t, --threshold=DOUBLE   Threshold for suboptimal matching results
                           (default='1.0')
  -c, --conf-file=FILE     Read configurations from file

Debugging:
  --debug                 Debug output: mostly traces of function calls.
                           (default=off)
  --bug                   Show helpful information (version number,
                           compilation date, compiler version, and
```

```
platform) in case a bug was found and should
be reported. (default=off)
--stats          Display time and memory consumption on
                  termination. (default=off)
--tmpfile=FILENAME Set the path and name of temporary files
                  (default='/tmp/rachel-XXXXXX')
--noClean       Do not delete temporary files. (default=off)
```

3.2 Configuration Files

The parameters of the simulation and matching algorithm can be controlled using a configuration file that can be read using the ‘`conf-file`’ option; for example:

```
rachel --automaton=impl.og --og=spec.og --conf-file=rachel.conf
```

A configuration file consists of `parameter = value` lines, each line setting the value of a parameter. An example file ‘`rachel.conf`’ is located in the ‘`src`’ folder.

Note: If not all parameters are defined, the standard values apply. Mandatory command-line options such as ‘`mode`’ (‘`m`’) cannot be defined in configuration files.

4 Version History

Rachel is developed under the “Release Early, Release Often” maxime (see <http://catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/ar01s04.html>): Whenever enough integrated or a non-trivial changes have summed up, a new version is published. Though this releases might now always mark significant changes, they at least allow to quickly fix bugs and avoid infinite procrastination.

Version 1.14 (18 January 2010)

- updated maintainer scripts
- added scripts to use LCOV (<http://ltp.sourceforge.net/coverage/lcov.php>) to determine test case coverage (use ‘make cover’ in ‘tests’ directory)
- added scripts to use ZCOV (<http://minormatter.com/zcov>) to determine test branch case coverage (use ‘make cover-branch’ in ‘tests’ directory)
- cleaned code:
 - removed support for aspects – not used any more
 - removed BPMN output – this does not belong here
 - removed 2-bit annotation – Wendy can do this
- implemented Wendy’s new IG/OG formats
- added target for benchmarks (execute ‘make bench -C tests’)
- implemented parameter ‘--stats’ to display information on runtime and memory consumption (the latter uses `ps` and does not work under Cygwin)
- colored status messages

Version 1.13 (6 June 2009)

- the bit annotations are now written inside the nodes of the Graphviz dot annotation
- service automata can be drawn as Graphviz dot graphs using mode ‘sa’ combined with ‘--dot’ (‘-d’)
- removed ‘--noop’ flag
- reorganized and cleaned up Dot output; in case of calculating an edit distance, only the result is printed; use mode ‘og’ or ‘sa’ to create a graphic for the input files
- moved command line parameters for GNU Gengetopt from Makefile to file ‘cmdline.ggo’
- adapted maintainer scripts for binary distributions to match the filenames used in Fiona
- Rachel can be translated using the LLVM-frontend for GCC (see <http://llvm.org/>)
- updated ‘Doxyfile’ and moved in into the ‘doc’ directory; the documentation can be created using ‘make doxygen’ which creates the directory ‘doc/doxygen’
- made adaptations to the Makefile options to be able to create Mac Universal binaries for 64 bit architectures (XCode 3.0 with SDK ‘MacOSX10.5.sdk’ is needed)
- if Graphviz dot has not been found by the configure script, the dependent tests are skipped instead of throwing an error
- tests are now organized by GNU Autotest

Version 1.12 (17 January 2009)

- implemented methods to calculate a compact representation of the formulae annotated to the operating guideline's states according to the paper submitted to ACS D 2009; the new method can be triggered with the new mode `'-m annotation'`
- in mode `'-m annotation'`, the `'--dot'` (`'-d'`) parameter creates a version of the input operating guidelines in which the explicit formulae are replaced by different colors representing the bit representation
- File input options `'--og'` (`'-o'`) and `'--automaton'` (`'-a'`) are now optional for Gengetopt, but are checked in the `'main.cc'` file. This was necessary, because the `'-m annotation'` mode did not need to parse a service automaton.
- implemented a mode `'-m bpmn'` to create a rudimentary BPMN (Business Process Modeling Notation) output in Graphviz dot format of a service automaton (given by `'--automaton'`); the path of the used stencils can be changed with `'--shapedir'`
- when using the `'--dot'` (`'-d'`) parameter, a PNG (Portable Network Graphics) file is now only created if the parameter `'--png'` is given
- overworked and beautified Graphviz dot output for operating guidelines: annotated formulae now use mathematical symbols for conjunctions and disjunctions, and the initial state is marked

Version 1.11 (2 November 2008)

- implemented Fiona's modified OG file format (an OG file now also consists of an interface definition) and adjusted the respective test cases — note that Rachel's parser is backwards compatible and still accepts OG files without interface definition
- renamed configure script parameter `'--enable-use64bit'` to `'--enable-64bit'` to achieve parameter compatibility with Fiona
- explicitly handling the disabling of assertions (with parameter `'--disable-assert'`) similar to Fiona's configure script
- canonized names of constants generated for file `'src/config.h'` and adjusted the output of the `'--bug'` parameter
- removed unnecessary files `'src/getopt.c'`, `'src/getopt1.c'`, and `'src/getopt.h'`
- used option `'gnits'` for Automake, see <http://www.gnu.org/software/automake/manual/automake.html>
- moved acknowledgements from file `'AUTHOR'` to file `'THANKS'` to meet the strict Gnits requirements
- updated documentation
- the configure script now takes care about the compilation flags; for example `./configure --enable-64bit` sets the flags necessary to build a 64 bit executable with `make`
- adapted code to avoid warnings of GCC 4.2 (mostly deprecation warnings)
- overworked test scripts: creation of output files is checked now
- simplified header inclusion: all typedefs are now made in `'types.h'`
- added a command line parameter `'--threshold'`/`'-t'` to set a threshold to control the matching algorithm: whenever a formula's assignment reaches this value, it is immediately returned instead of the optimum; this results in faster, yet sub-optimal results

Version 1.10 (20 August 2008)

- Rachel does not need to be installed to execute `make experiments`
- added configure script parameter `'--enable-universal'` to set flags to build a Mac universal binary (<http://www.apple.com/universal>)

- added configure script parameter ‘`--enable-win32`’ to set flags to build a Windows binary which uses the MinGW framework (<http://www.mingw.org>) to be independent of the ‘`cygwin1.dll`’ provided by Cygwin (<http://www.cygwin.com>)
- added configure script parameter ‘`--enable-use64bit`’ to set flags to build a 64 bit binary (e.g. for `x86_64`, `ppc64`, or 64-Bit SPARC)
- chosen configure script parameters are printed when using ‘`--bug`’ command line parameter
- made the configure script option ‘`--disable-aspects`’ standard
- added a command line parameter ‘`--noop`’ to exit after parsing the input files – mostly for debug information, e.g. if you want to count the services characterized by an OG (combined with ‘`--verbose`’)
- fixed a bug: the requirements to calculate matching-based edit distance (final states are sink states) led to incorrect formula evaluation (see <https://gna.org/bugs/?11944>) when calculating the number of characterized services
- removed orphaned code for linear programming
- added more test cases (also expected failures)
- added code coverage checks using LTP LCOV (<http://ltp.sourceforge.net/coverage/lcov.php>); checks can be invoked in directory ‘`tests`’ with `make prepare-cover cover`

Version 1.09 (7 August 2008)

- fixed bug #12153 (<https://gna.org/bugs/?12153>): the patch for the aspected sources now works on `x86_64` machines
- fixed a bug in test script ‘`tests/test4`’: the wrong return value was returned to `make check`
- improved portability of Makefiles by using more built-in variables such as `$(MAKE)` `$(AM_MAKEFLAGS)` or `$(SED)`
- added file ‘`doc/cmdline.out`’ to the distribution to avoid complete compilation just to execute `make doc`
- code complies to ISO C++
- listing the tools required to re-generated code (Flex, Bison, Gengetopt, and Kimwitu++) in the ‘`README`’ file
- completed task #6131 (<https://gna.org/task/?6131>): whether or not the aspects of AspectC++ are used during compilation can be controlled by parameters of the configure script:
 - `./configure`: use aspects
 - `./configure --enable-aspects`: use aspects
 - `./configure --enable-aspects=true`: use aspects
 - `./configure --disable-aspects`: do not use aspects
 - `./configure --enable-aspects=false`: do not used aspects

If aspects are disabled, the files ‘`src/xxxx.cc`’ are directly copied to ‘`src/aspected-xxxx.cc`’, and the AspectC++ tools are not at all invoked.

- MAINTAINER: overworked the Makefile target ‘`deb`’ in the directory ‘`maintainer`’ to create a Debian source package

Note that `make deb` can only be executed on a machine where the tools `dpkg-buildpackage` and `date -R` are present. To upload the source package to a Launchpad PPA (it is currently uploaded to <https://launchpad.net/~niels-lohmann/+archive>), the tool `dput` is needed. Furthermore, the tools `fakeroot` and `alien` are needed to create an RPM binary package from the Debian binary package.

Version 1.08 (3 August 2008)

- MAINTAINER: added a directory ‘maintainer/debian’ containing files to create Debian and Redhat packages
- MAINTAINER: moved maintenance Makefile targets (‘upload’) to ‘maintainer’ directory
- the file ‘NEWS’ is now extracted from file ‘doc/ChangeLog.texi’

Version 1.07 (29 July 2008)

- fixed bug #12112 (<https://gna.org/bugs/?12112>): allow to compile Rachel using GCC 4.3.1
- some changes in the way the change log is created
- minor changes to avoid compiler warnings

Version 1.06 (16 July 2008)

- added a Makefile target `make bindist` to create a zipped archive with a binary and a documentation
- added an undocumented command line option ‘`--bug`’ to display debugging information that is meant to be emailed to the bugreport address in case a bug is found; looks like:

```
Please email the following information to rachel@service-technology.org:
- tool:                Rachel
- version:             1.06
- compilation date:   Jul 16 2008
- compiler version:   4.0.1 (Apple Inc. build 5484)
- platform:           i386-apple-darwin9.4.0
```

- minor changes in Makefiles and configure script
- updated ‘src/Doxyfile.in’ template for doxygen version 1.5.5

Version 1.05 (8 July 2008)

- fixed a memory leak in the OG lexer
- fixed a memory leak in the command line parser

Version 1.04 (30 June 2008)

- added the experiments (file ‘exp/bpm2008.tgz’) from the paper
Niels Lohmann. **Correcting Deadlocking Service Choreographies Using a Simulation-Based Graph Edit Distance**. In Marlon Dumas, Manfred Reichert, and Ming-Chien Shan, editors, *Business Process Management, 6th International Conference, BPM 2008, Milan, Italy, September 1–4, 2008, Proceedings*, volume 5240 of Lecture Notes in Computer Science, pages 132–147. Springer-Verlag, September 2008.
- experiments can be invoked using `make experiments`
- added PDF document (file ‘doc/background.pdf’) containing the paper
Niels Lohmann. **Fixing Deadlocking Service Choreographies Using a Simulation-based Graph Edit Distance**. In Monika Solanki, Barry Norton, and Stephan Reiff-Marganiec, editors, *3rd Young Researchers Workshop on Service Oriented Computing, YR-SOC 2008, London, UK, 12–13 June 2008, Proceedings*, pages 13–20, June 2008.
- overworked the documentation

Version 1.03 (22 June 2008)

- some adjustments to improve the compatibility between AspectC++ (<http://www.aspectc.org>) and Cygwin

Version 1.02 (14 May 2008)

- added more files to the deletion list of Makefile target `cvs-clean`
- acknowledged service-technology.org where possible (e.g., in the bug address rachel@service-technology.org)
- adjusted the parser to cope with Fiona’s new OG file format; Rachel’s parser stays backward compatible
- the parser now aborts the program in case of an error to avoid subsequent crashes caused by parse errors
- the lexer was overworked to be backward compatible with older Flex versions

Version 1.01 (6 May 2008)

- adding copyright notices to comply to the GNU GPL
- added comments
- overworked documentation

Version 1.00 (6 May 2008)

- tool is now called Rachel = “**R**epairing **A**utomata for **C**horeographies by **E**ditng **L**abels”
- adjusted the parameters: changing is now preferred over deletion and insertion
- the service counting function `Graph::countServices` now uses `long double` to count up to 10^{4932}
- added a function to calculate the average size of satisfying assignments of the OG’s nodes (called with ‘`verbose`’ parameter)
- added a preprocessing function to calculate values for node deletion in advance

Version 0.20

- the check for acyclicity is done right after parsing and not during matching or simulation calculation
- added a function to re-enumerate the graphs’ nodes to allow the usage of C-style arrays
- finally, using C-style multidimensional arrays to cache simulation values in `Simulation` and `Matching` classes
- re-organized `Simulation` and `Matching` classes: both now inherit from a new class `EditDistance` to avoid replication of code

Version 0.19

- the aspected sources are automatically patched such that `size_t` is used instead of `unsigned long` in the generated `new-operator`
- `lp_solve` is currently not integrated for unsolved compatibility problems — an archive ‘`lp-solve.tar.gz`’ is still in the ‘`src`’ folder
- documented usage of configuration files and added a sample configuration file
- `matching` is now the standard for the ‘`--mode`’ parameter
- added a preprocessing function to calculate values for node insertion in advance

- added a function to count the deterministic acyclic services characterized by the OG (called with ‘`verbose`’ parameter)
- the ChangeLog is automatically generated from the Texinfo sources

Version 0.18

- overworked Makefiles
- manpage now shows result for ‘`--detailed-help`’
- added a ‘`--debug`’ mode to trace all function calls of classes `Matching` and `Simulation`
- added a ‘`--verbose`’ mode to display intermediate progress output
- using AspectC++ (<http://www.aspectc.org>) to add aspects like the trace calls
- added a great optimization in function `Matching::permuteEdges` by avoiding subsequent deletion and insertion of the same edge
- the ChangeLog is automatically integrated into documentation using a sed script

Version 0.17

- overworked documentation
- caches are cleared after simulation/matching has been calculated
- more comments

Version 0.16

- cleaned and commented code
- tidied Makefiles
- added a testscript for linear programming translation
- commented linear programming translation
- linear programming translation is by `lp_solve` library
- dramatically improved performance of `Matching::perms()` function

Version 0.15

- added a linear programming calculation for simulation (‘`--mode=lpsim`’)
- the translation to linear programming bases on the algorithm presented in the paper "Simulation-based graph similarity" by Oleg Sokolsky et al. (TACAS 2006)
- added `lp_solve` (<http://lpsolve.sourceforge.net/5.5>) to the distributed and linked it as static library (see ‘`src/lp_solve/README.txt`’ for more information)
- the ‘`--mode`’ parameter is now passed as enumeration from `getopt`

Version 0.14

- added testscripts for `make check`
- cache for simulation is again handled by an STL map

Version 0.13

- Tool is now called “WS-Fix”
- first release at <http://www.informatik.uni-rostock.de/~nl/tools>
- added cycle detection

Version 0.12

- Dot and PNG (Portable Network Graphics) file is created when ‘`--dot`’ parameter is used
- extension and path is cropped from filenames to avoid errors from Dot
- reorganized files: helper functions moved to ‘`helper.cc/h`’
- fixed header inclusion to allow compilation on Unix machines
- added a Texinfo documentation
- using C-style multidimensional arrays to cache simulation values
- some statistical output in the main function
- the cost functions are declared as inline functions

Version 0.11

- removed Gnuilib again and replaced it by ‘`getopt1.c`’, ‘`getopt.c`’, and ‘`getopt.h`’
- usage line is now generated by GNU Gengetopt
- a manpage is created using `help2man`
- values of the algorithm can be configured using the command line or a configuration file

Version 0.10

- GNU Gengetopt is not needed to configure/make
- Automake’s missing script is found
- included headers for `assert` macro
- tidied configure script
- using Gnuilib – The GNU Portability Library (<http://www.gnu.org/software/gnuilib>) to provide ‘`getopt.h`’

Version 0.9

- using GNU Gengetopt (<http://www.gnu.org/software/gengetopt>) to parse command line parameters
- added parameter ‘`-h`’ for help
- added parameter ‘`-V`’ for version information
- added parameter ‘`-a`’ for automaton file
- added parameter ‘`-o`’ for OG file
- added parameter ‘`-m`’ to select mode (standard: `simulation`)

Version 0.8

- the edit actions are annotated to a graph and can be dotted

Version 0.7

- new nodes are rather added than inserted
- nodes are only inserted once
- nodes are rather deleted than merged
- newly added nodes are not considered in function `successor()` or `outEdges()`
- newly added nodes are dotted as dashed nodes

Version 0.6

- implemented `isFinal()` check to test whether final satisfies a formula of the OG
- the root node is now read from file instead of being assumed to be 1
- nodes are explicitly stored to allow future operations such as adding nodes

Version 0.5

- matching now returns the action edit actions and outputs them
- added Doxygen configuration file
- reorgaized headers again (added headers for simulation)

Version 0.4

- parsed annotations are now used for simulation and matching
- reorganized headers (split omnipresent `'main.h'`)

Version 0.3

- annotations are parsed, but not used for calculation
- Dot output for graphs implemented

Version 0.2

- added parser for OG files (taken and adapted from Fiona (<http://www.informatik.hu-berlin.de/top/tools4bpel/fiona>))
- currently ignores the annotations, but already works for service automata (simulation checking)

Version 0.1

- simulation implemented
- matching rudimentarily implemented
- using GNU autotools

The most recent change log is available at Rachel's website at <http://service-technology.org/files/rachel/ChangeLog>.

Appendix A The GNU Free Documentation License

Version 1.3, 3 November 2008

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