



RegSTAB

<http://regstab.forge.ocamlcore.org/>

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1 Description

RegSTAB is a SAT-solver extended to handle formula schemata i.e. constructions of the form $\bigwedge_{i=1}^n \neg P_i \vee P_{i+1}$. Such schemata are considered to be unsatisfiable iff all propositional formulae of the corresponding form are unsatisfiable.

It is generally not possible to automatize the (un)satisfiability of such objects. So RegSTAB is restricted to a specific form of schemata called “regular schemata”. Hence the part “Reg” of RegSTAB. Furthermore RegSTAB is based on an extension of propositional tableaux called STAB. Hence the part “STAB” of RegSTAB. This is all described in detail in [ACP09b].

This is quite unusual to use propositional tableaux for a SAT-solver but this is much more natural to use tableaux rather than DPLL to handle schemata [ACP09a]. As a pure SAT-solver RegSTAB is all the least efficient. But one can easily think of combining RegSTAB with an efficient SAT-solver in order to benefit of both worlds.

2 Install

Preamble: install on Windows seems rather painful, if you agree then complain!

2.1 GODI

The simplest way to install RegSTAB is to use GODI¹. GODI is a package manager for Ocaml libraries and software. It has many many advantages for Ocaml apps developpers.

Currently, the official version of GODI relies on ocaml 3.10, there is a beta version of GODI for ocaml 3.11.1². See GODI documentation and install the package “apps-regstab”. The following will be installed (<PREFIX> is GODI base directory):

- `regstab`, `regstab.opt` (if any), `sch2cnf`, `sch2cnf.opt` in <PREFIX>/bin.
- The manual (this file) into <PREFIX>/doc/apps-regstab/.
- The man pages into the directory <PREFIX>/man/man1/.
- The developer doc into the directory <PREFIX>/share/apps-regstab/developer.doc.
- The vim syntax file into the directories `$HOME/.vim/syntax` and <PREFIX>/share/apps-regstab/vim.

¹<http://godi.camlcity.org/godi/index.html>

²<http://download.camlcity.org/download/godi-rocketboost-20090421.tar.gz>

2.2 Good Old Make

Steps:

1. `make all`

Compile the byte-code version of RegSTAB.

2. (Optional) `make opt`

Compile the native-code version of RegSTAB if possible on your machine (→ executable `regstab.opt`).

3. (Optional) `make test`

Run tests.

4. `make install`

- Copy the files `regstab`, `regstab.opt` (if any), `sch2cnf`, `sch2cnf.opt` into the directory `$PREFIX/bin`.
- Copy the manual (this file) into the directory `$PREFIX/doc/regstab/`.
- Copy the man pages into the directory `$PREFIX/man/man1/`.
- Copy the developer doc into the directory `$PREFIX/share/regstab/developer.doc`.
- Copy the vim syntax file into the directories `$HOME/.vim/syntax` and `$PREFIX/share/regstab/vim`.

The environment variable `PREFIX` defaults to `/usr/local`.

Dependencies.

1. the Ocaml compiler, tested with 3.11.1³
2. the Findlib library manager, tested with 1.2.4⁴
3. the OMake build system, tested with 0.9.8.5⁵
4. the Jane Street Core library, tested with 0.5.3⁶

And possibly:

- If you're under Windows: CygWin⁷.
- If you want to run tests: OUnit⁸

Notice that all those dependencies, except CygWin, can be handled through GODI.

³<http://caml.inria.fr/index.en.html>

⁴<http://projects.camlcity.org/projects/findlib.html/>

⁵<http://omake.metaprl.org/index.html>

⁶<http://ocaml.janestreet.com/?q=node/13>

⁷<http://www.cygwin.com/>

⁸<http://www.xs4all.nl/~mmzeeman/ocaml/>

2.3 Intel Mac OSX Binaries

The Intel Mac OSX archive contains the following:

- `regstab.opt`: Intel Mac OSX native executable
- `regstab`: Machine-independent bytecode executable
- `bin/`: Contains `sch2cnf`, `sch2cnf.opt` and copies of `regstab` and `regstab.opt`
- `doc/`: Contains the manual `manual.pdf` (this file)
- `examples/`: Contains examples
- `man/man1/`: Contains the man pages for `regstab`, `regstab.opt`, `sch2cnf`, `sch2cnf.opt`
- `tools/`: Contains `regstab.vim` the vim syntax file for RegSTAB files

2.4 Machine-Independant Bytecode

Warning: the bytecode version of RegSTAB is much slower than the native one (2s vs. 30s for `examples/adder4.stab` on my machine). Though you may have no other choice: e.g. if your architecture is not supported by the OCaml native compiler (very rare) or by one of the dependencies (e.g. Windows without Cygwin)

The Bytecode archive contains the following:

- `regstab`: Machine-independent bytecode executable
- `bin/`: Contains `sch2cnf` and a copy of `regstab`
- `doc/`: Contains the manual `manual.pdf` (this file)
- `examples/`: Contains examples
- `man/man1/`: Contains the man pages for `regstab` and `sch2cnf`
- `tools/`: Contains `regstab.vim` the vim syntax file for RegSTAB files

3 Usage

```
regstab.opt [-verbose] [file]
regstab [-verbose] [file]
```

Prints `unsatisfiable` (resp. `satisfiable`) if the input formula is unsatisfiable (resp. satisfiable). If no file is provided the input formula is taken on `stdin`.

Options:

- **-verbose** Be verbose, currently only displays the input formula after parsing. Allows to check that the input formula is indeed the formula understood by RegSTAB.

4 (Informal) Language Definition

4.1 Propositional Formulae

- Usual logical notations are translated into ASCII: \wedge stands for the conjunction (\wedge), \vee stands for the disjunction (\vee), \sim stands for the negation (\neg).
As a convenience some other usual connectives are pre-defined: $P_1 \rightarrow P_2$ stands for the implication ($P_1 \Rightarrow P_2 := \neg P_1 \vee P_2$), $P_1 \leftrightarrow P_2$ stands for the equivalence ($P_1 \Leftrightarrow P_2 := (P_1 \Rightarrow P_2) \wedge (P_2 \Rightarrow P_1)$), $P_1 (+) P_2$ stands for the exclusive or ($P_1 \oplus P_2 := \neg(P_1 \Leftrightarrow P_2)$),
- Propositional variables must be indexed: you can't write $A \wedge (B \vee C)$ but $P_1 \wedge (P_2 \vee Q_1)$ is ok. They can be any alphanumerical sequence starting with an uppercase letter. Prime (') can be appended to the sequence. The index may be any integer.
- Formulae must be in negative normal form i.e. negation can only occur just in front of a propositional variable: you can't write $\sim(P_1 \wedge P_2)$ but $\sim P_1 \vee \sim P_2$ is ok.
- Precedence of connectives is as follows: $\wedge > \vee > (+) > \leftrightarrow, \rightarrow$.

4.2 Schemata

Syntax:

- Iterated conjunctions are written " $\wedge_{i=k..e}$ " where i is a variable, k is an integer, and e is an arithmetic expression. k is called the *lower bound* of the iterated conjunction, e is its *upper bound*. Iterated disjunctions are written similarly with \vee instead of \wedge .
- Arithmetic expressions are written " $n+k$ " or " $n-k$ " where n is a variable and k is a natural number.
- Inside iterations indexed propositional variables are written " P_e " where P is a propositional variable (defined in 4.1) and e is an arithmetic expression. *Do not put parentheses around e .*
- Variables can be any alphanumerical sequence starting with a lower case letter. Prime (') can be appended to the sequence.

- Iteration operators have the highest precedence: $\wedge_{i=0..n} P_i / \wedge P_{i+1}$ is interpreted as $(\wedge_{i=0..n} P_i) / \wedge P_{i+1}$, and not $\wedge_{i=0..n} (P_i / \wedge P_{i+1})$ (think of the body of the iteration as being an argument given to the operator $\wedge_{i=0..n}$).

Example: $P_1 \wedge \wedge_{i=1..n-1} (P_i \rightarrow P_{i+1}) / \sim P_n$

Restrictions:

- *Iterations cannot be nested:* you cannot write $\wedge_{i=1..n} (\wedge_{j=1..n} \dots)$
- *There may be only one free variable* (called the *parameter* of the schema): you cannot write $\wedge_{i=1..n} P_i \wedge \wedge_{i=2..p} Q_i$.
- *All iterations must have the same lower bound*⁹: you cannot write $\wedge_{i=1..n} \dots \wedge_{i=2..n} \dots$
- *For P_e occurring in some iteration, the only variable that can occur in e is the variable which is iterated*¹⁰ you cannot write $\wedge_{i=1..n} P_{n+1}$ but $\wedge_{i=1..n} P_{i+1}$ is ok.

4.3 Constraints

Basic constraints can be given on the parameter of a schema. They must be inserted after the schema and are written “ $| n \text{ op } k$ ” where n is the parameter of the schema, k is an integer, and $op \in \{<, <=, =, >=, >\}$

Example:

$P_1 \wedge \wedge_{i=1..n-1} (P_i \rightarrow P_{i+1}) / \sim P_n \mid n > 0$

Notice that this example is unsatisfiable with the constraint but is satisfiable without it: if we take $n=0$ we get the formula $P_1 / \sim P_0$ which is satisfiable. As schemata are considered to be unsatisfiable iff all propositional formulae obtained by giving a value to n are unsatisfiable, this schema is not satisfiable.

4.4 Functions

To ease the input you can define simple functions. E.g. if you use often $A_i \rightarrow A_{i+1}$ with a different A (say $B_i \rightarrow B_{i+1}$, $C_i \rightarrow C_{i+1}$, ...), then you can factorize this by defining a function $\lambda X \cdot X_i \Rightarrow X_{i+1}$. The syntax is as follows: `let F(X) := X_i -> X_{i+1} in ...`

- The name of a function follows the same conventions as propositional variable names.

⁹This can be easily circumvented if $n > 1$ by manually unfolding the first ranks: $\bigwedge_{i=1}^n S_i \wedge \bigwedge_{i=2}^n T_i$ is equivalent, if $n > 1$, to $S_1 \wedge \bigwedge_{i=2}^n S_i \wedge \bigwedge_{i=2}^n T_i$

¹⁰This can be easily circumvented by factorising the constant indexed proposition: $\bigwedge_{i=1}^n (P_n \vee P_i)$ is equivalent to $P_n \vee \bigwedge_{i=1}^n P_i$. Maybe we should automatize this.

- The parameters of the function is a comma separated list comprised between parentheses if the list is non-empty. *The parameters may be either propositional variable names or simple variable names.* E.g. you can write `let F(X,n) := X.n ->X.n+1 in ...`
- The right member of the affectation is any formula as defined previously. It cannot contain a constraint.

Calling the function is done, e.g., as follows: `F(P,n+1)`, i.e. the name of the function followed by the list of parameters enclosed between parentheses. *When there is no parameter, you should still put parentheses, i.e. F().*

Full Example:

```
let F(S,A,B,C,i) := S_i <-> (A_i(+)B_i(+)C_i-1) in
/\i=1..n (F(S,A,B,C,i) \/\ F(S',A',B',C,i+1))
```

4.5 Comments

Comments start by `//` and end at the end of the line.

5 Examples

See the directory `examples`.

6 Tools

6.1 sch2cnf

```
sch2cnf.opt n [file]
sch2cnf n [file]
```

Computes the propositional formula obtained by giving the value n to the parameter of the input schema. Outputs the formula in DIMACS cnf format. Thus `sch2cnf` can be used as a generator of problems for SAT-solvers. If no file is provided the input formula is taken on `stdin`.

Options:

- cnf Forces the displayed formula to be in conjunctive normal form, only useful when `-H` is set.
- D Displays the formula in DIMACS cnf format (default)
- H Displays the formula in a human readable format

6.2 Vim syntax file

regstab.vim

Copy the file into `~/.vim/syntax/`. You can use modelines to force the syntax (see examples), you just have to add as the last line of your file:

```
// vim:ft=regstab
```

6.3 Man pages

Short man pages for quick recall are available in the directory `man`. If you do not wish to install RegSTAB you can access them with `man -M man/ regstab` or `man -M man/ sch2cnf` when in the top directory. However the full documentation is the present file.

7 Licence

Free domain.

References

- [ACP09a] Vincent Aravantinos, Ricardo Caferra, and Nicolas Peltier. A DPLL Proof Procedure For Propositional Iterated Schemata. In *Workshop Proceedings of the 21st European Summer School in Logic, Language and Information (Worskhop Structures and Deduction)*, 2009.
- [ACP09b] Vincent Aravantinos, Ricardo Caferra, and Nicolas Peltier. A Schemata Calculus For Propositional Logic. In *Proceedings of the 18th International Conference on Automated Reasoning with Analytic Tableaux and Related Methods (TABLEAUX 2009)*, LNCS. Springer, 2009.