# Symbolic Execution of Debian Packages

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IRIF, Université de Paris

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13th Alpine Verification Meeting

## Introduction

- CoLiS project: Correctness of Linux Scripts

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- Goal: applying formal methods to the quality assessment of Debian Packages.
- Debian: operating system.
- Packages: way to provide (install, update, remove) software.
- Goal (reformulated): making sure that installing/updating/removing software does not:
  - make other softwares unusable,
  - make the whole computer unusable,
  - remove your personnal files,
  - etc.

# Installing a Software on Debian

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   - This is a POSIX shell script ran as administrator.
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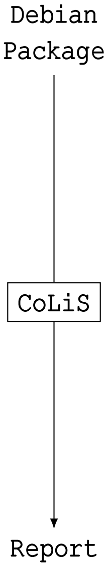
Complicated and dangerous. Formal methods?

# Our Tools: An Overview



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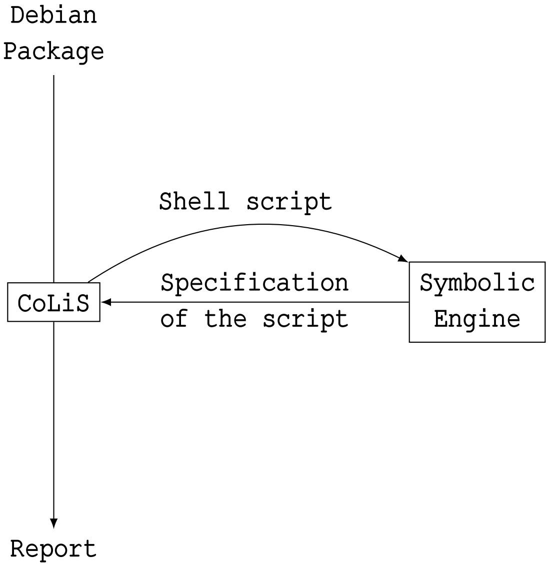

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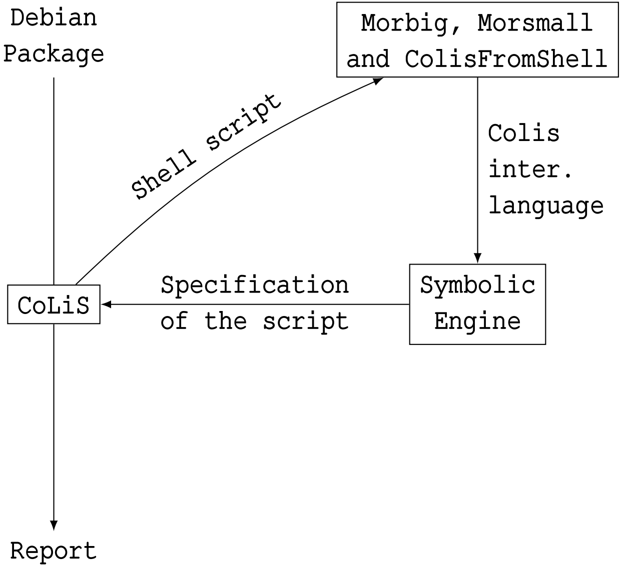

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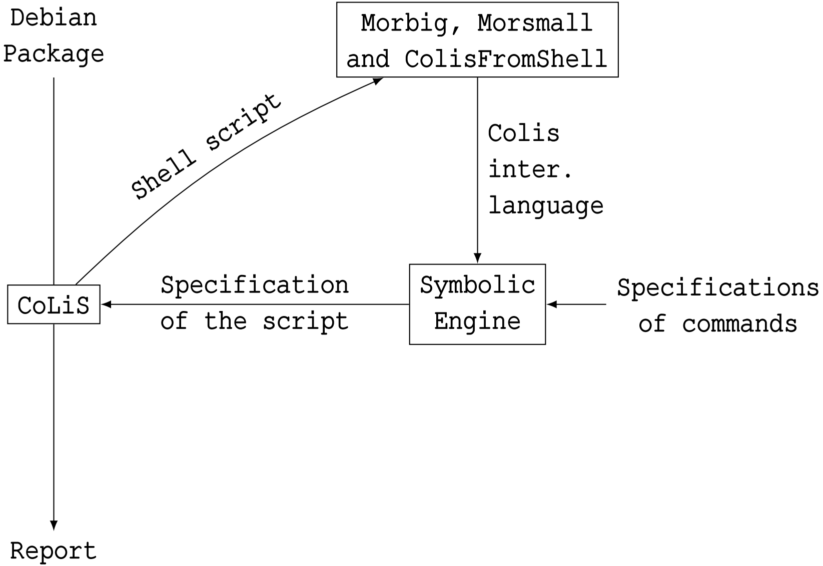

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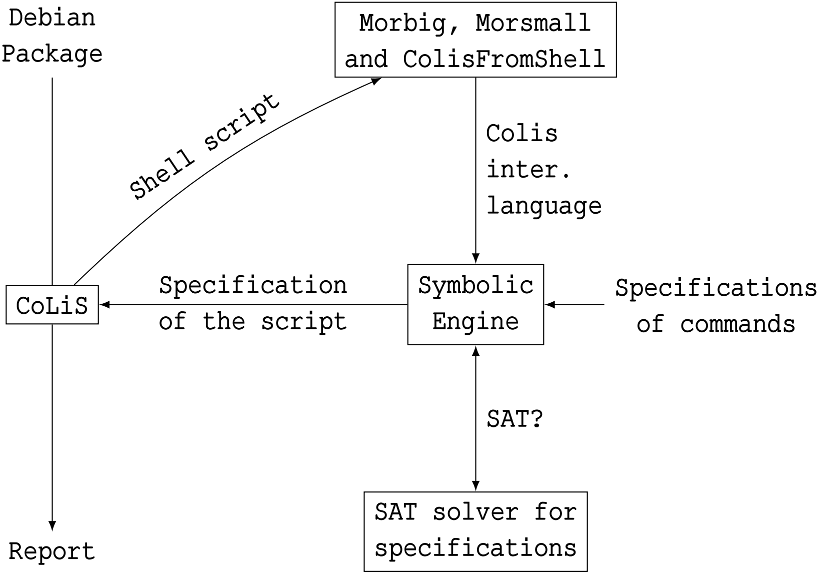
Debian Package
Morbig, Morsmall and ColisFromShell
Shell script
Colis inter. language
CoLiS
Specification of the script
Symbolic Engine
Specifications of commands
SAT?
Report
SAT solver for specifications

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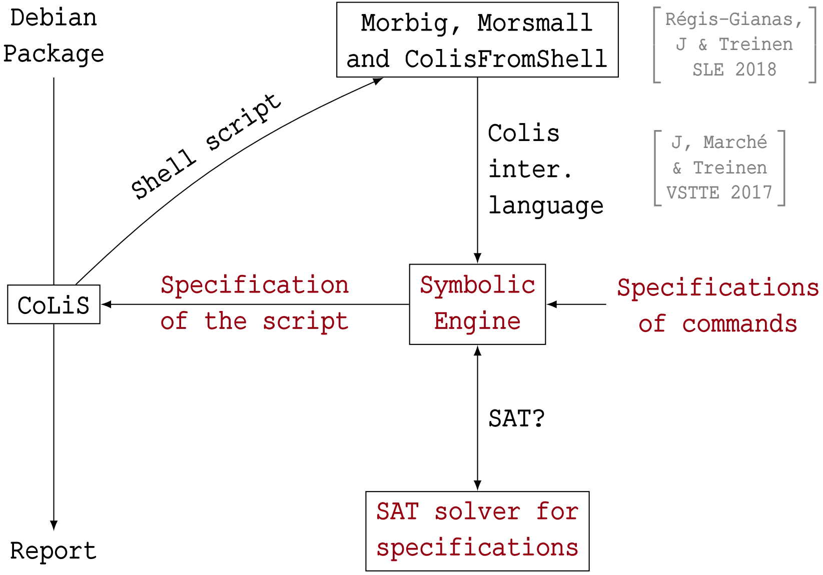
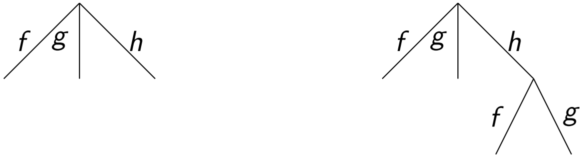


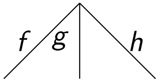
# Specifications,
# Feature Trees & Constraints

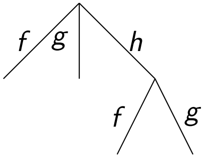
# Feature Trees



- Unranked unordered trees;

# Feature Trees





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- Good models for the UNIX filesystem;

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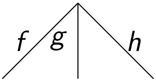

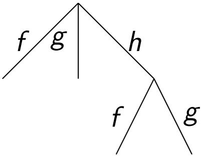

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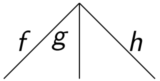

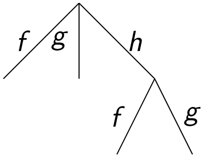

- Unranked unordered trees;
- Good models for the UNIX filesystem;
- Shell scripts can be seen as programs that modify such trees;
- Constraints will express relations between such trees.

# Constraints On Feature Trees

| Atom | (Informal) Semantics |
|---|---|

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| $x[f]y$ | From $x$'s tree, through $f$, we go to $y$'s tree |
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| $Ax$ | The root of $x$'s tree has decoration $A$ |

[Aït-Kaci Podelski & Smolka 1992]

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| $x[F]$ | $x$'s tree can also use features in $F$ | [Smolka & Treinen 1994] |
| $x \sim_F y$ | $x$ and $y$'s trees are similar except in $F$ | |

# Example Specification: mkdir q/f

$$\begin{aligned}&\exists x, x', y' \cdot \\ &\mathtt{resolve}(r, cwd, q, x) \land \mathtt{dir}(x) \land x[f]\uparrow \\ &\land \mathtt{similar}(r, r', cwd, q, x, x') \land x \sim_{\{f\}} x' \\ &\land \mathtt{dir}(x') \land x'[f]y' \land \mathtt{dir}(y') \land y'[\varnothing]\end{aligned}$$

Success

---

$$\exists y \cdot \mathtt{resolve}(r, cwd, q/f, y) \land r \doteq r'$$

---

$$\mathtt{noresolve}(r, cwd, q) \land r \doteq r'$$

Error

---

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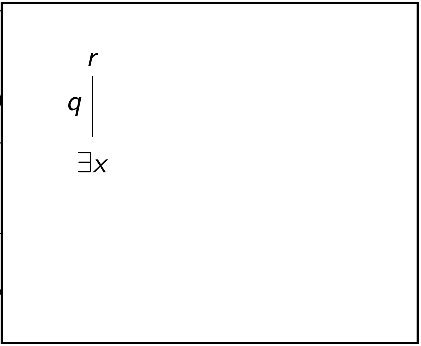

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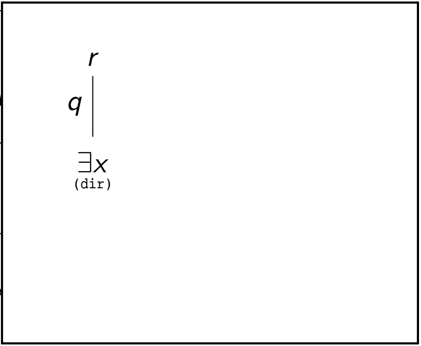

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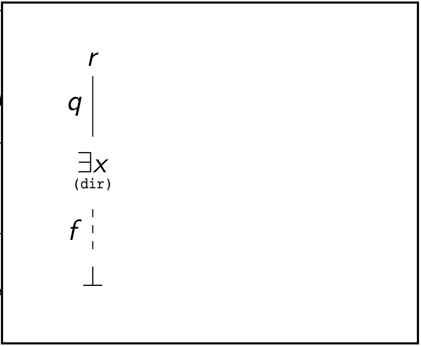

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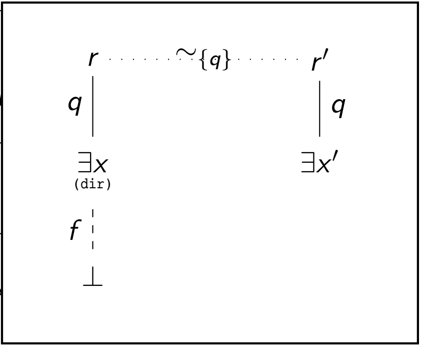

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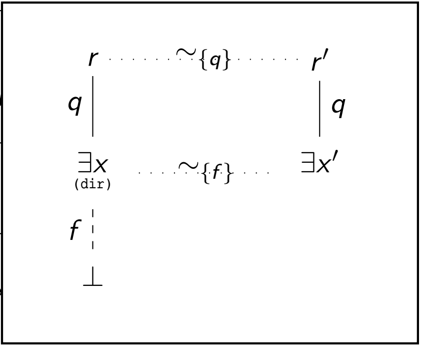

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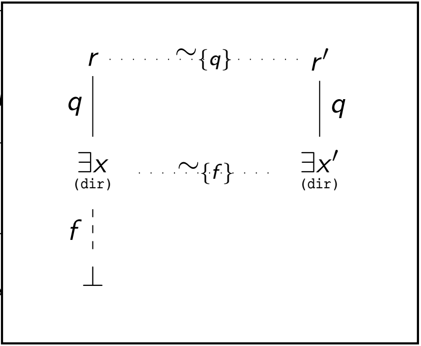

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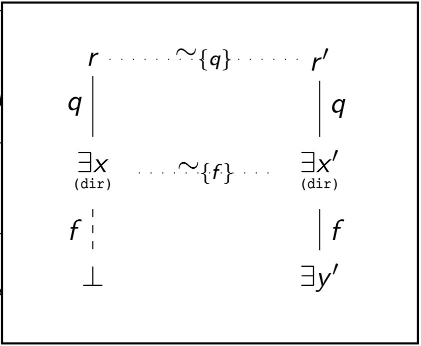

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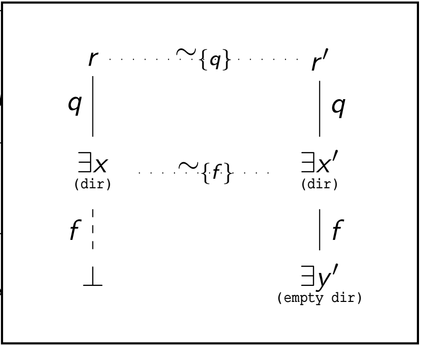

# Symbolic Execution

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if [ -e foo ]; then
  rm foo
fi
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---

In progress

$r$

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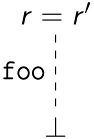
Case 1

Success



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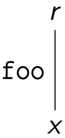

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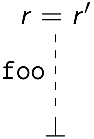
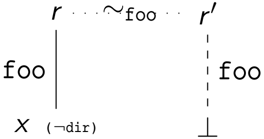


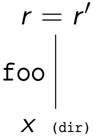
Case 2

Success



Case 3

Error

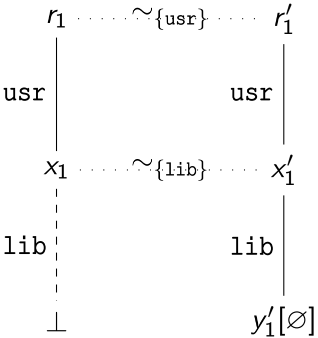


# Chaining Specifications

```
mkdir /usr/lib     ;     mkdir /usr/lib/foo
```

# Chaining Specifications

`mkdir /usr/lib ; mkdir /usr/lib/foo`



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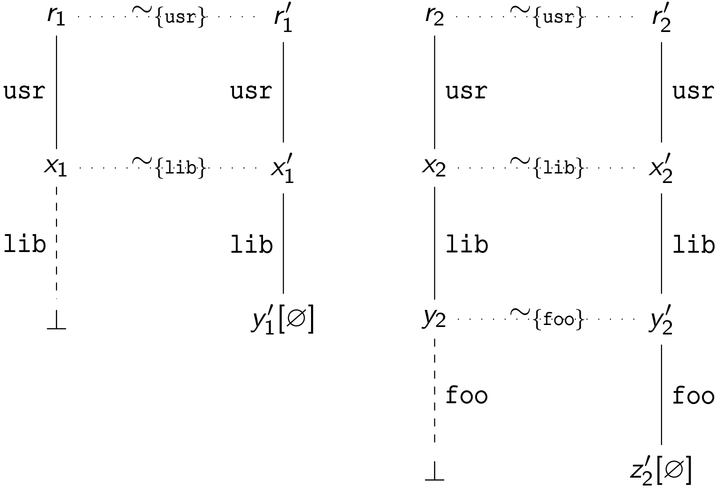

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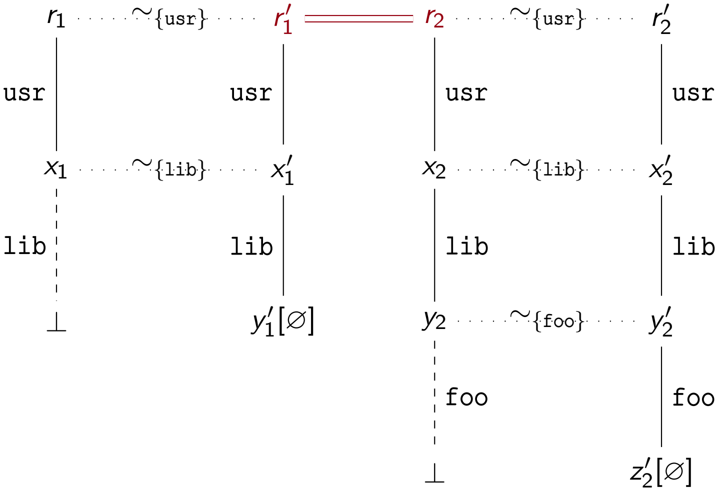
$r_1$ $\sim_{\{usr\}}$ $r'_1$
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usr
usr
usr
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lib
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lib
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$y'_1[\varnothing]$
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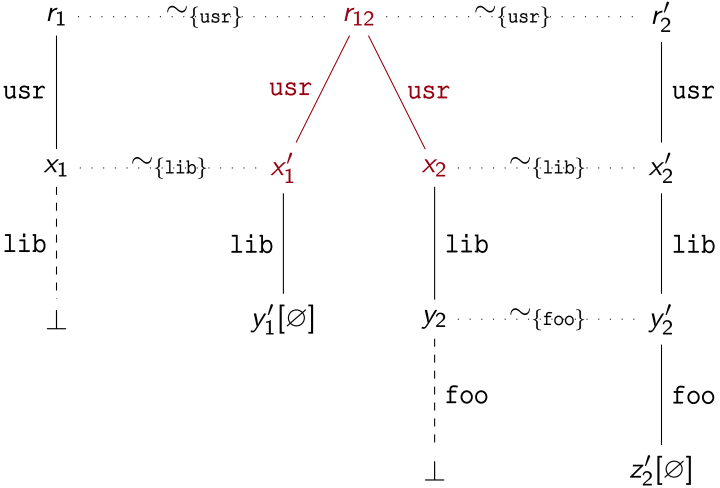

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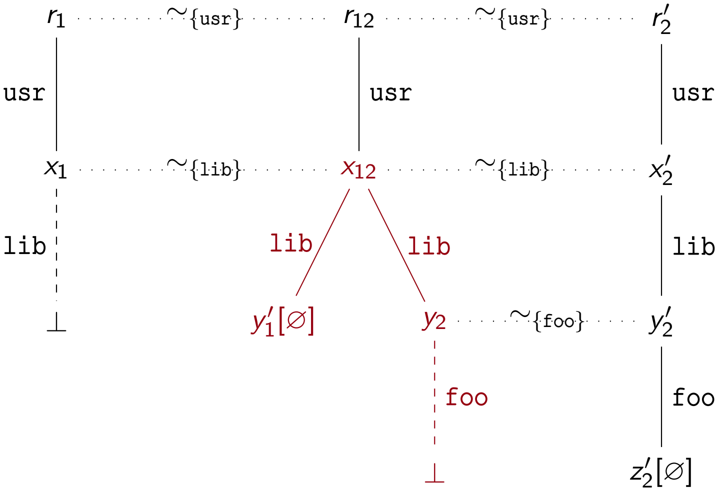

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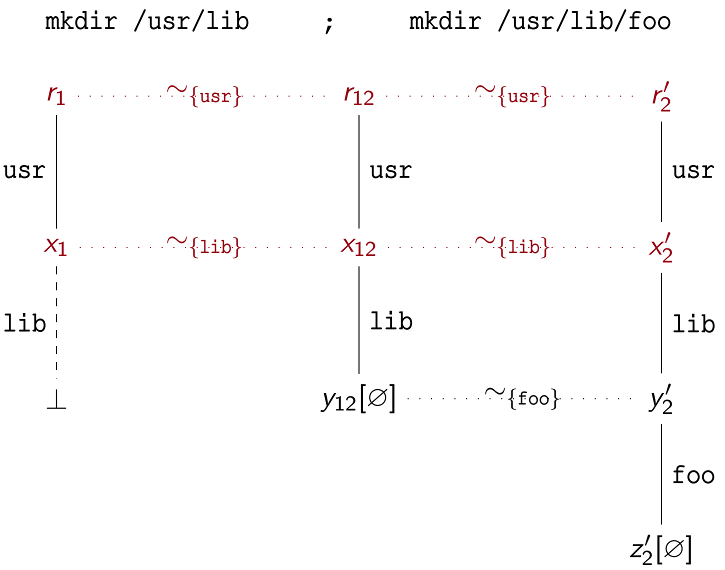

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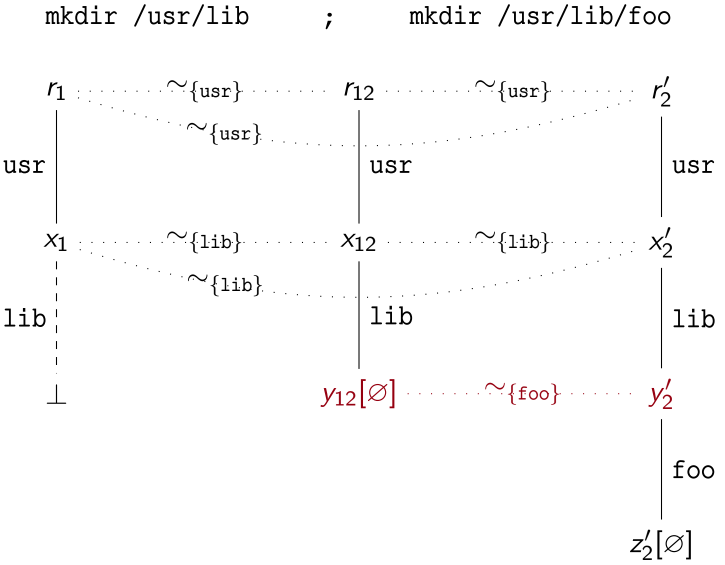
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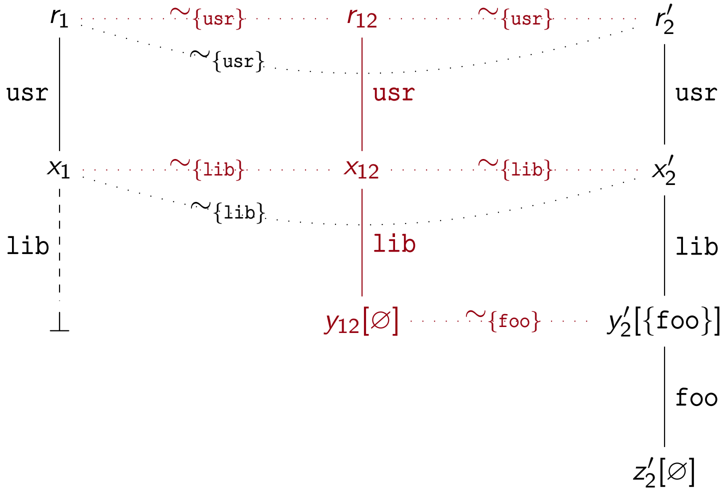
$x'_2$
$\sim_{\{\texttt{lib}\}}$
lib
lib
lib
$\perp$
$y_{12}[\varnothing]$
$\sim_{\{\texttt{foo}\}}$
$y'_2$
foo
$z'_2[\varnothing]$

# Chaining Specifications

`mkdir /usr/lib ; mkdir /usr/lib/foo`



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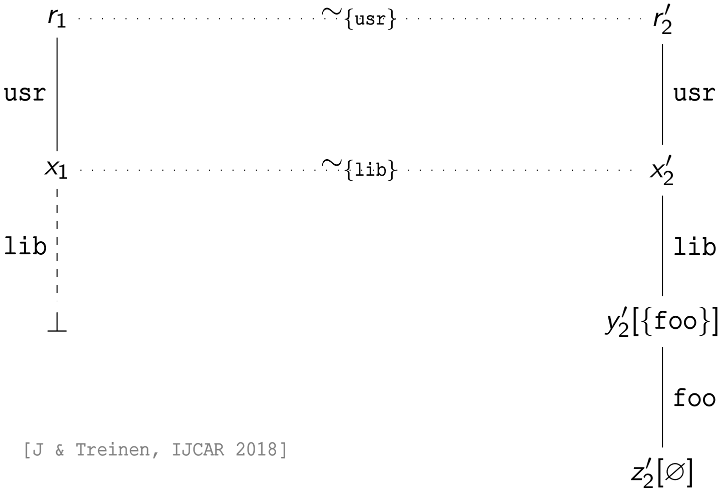
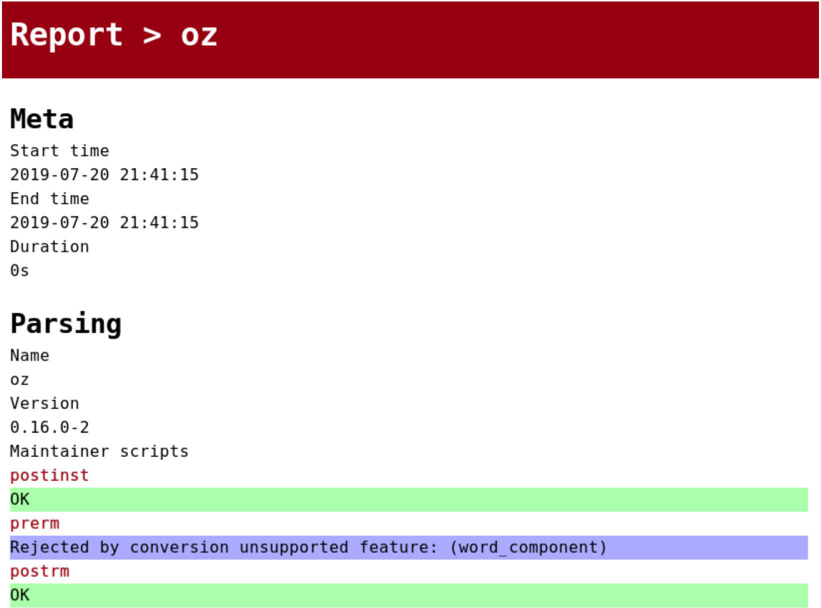


[J & Treinen, IJCAR 2018]

# Demo

# Package Report



## Report > oz

### Meta

Start time

2019-07-20 21:41:15

End time

2019-07-20 21:41:15

Duration

0s

### Parsing

Name

oz

Version

0.16.0-2

Maintainer scripts

postinst

OK

prerm

Rejected by conversion unsupported feature: (word_component)

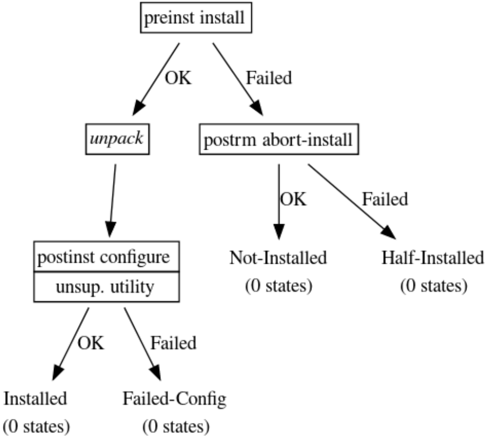
postrm

OK

# Installation Scenario

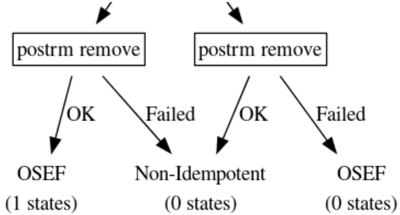
## Scenarii

### Installation



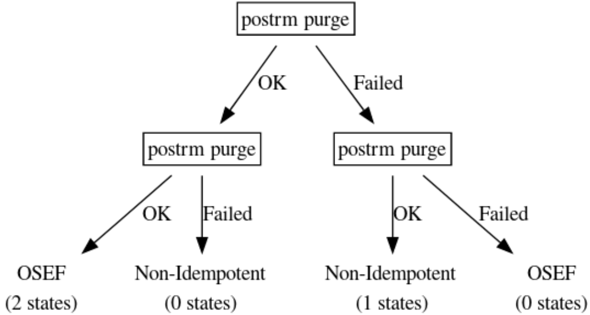
### Removal

# An Other Scenario



postrm remove
OK
Failed
OSEF
(1 states)
Non-Idempotent
(0 states)
postrm remove
OK
Failed
OSEF
(0 states)

## Idempotency of postrm purge



postrm purge
OK
Failed
postrm purge
OK
Failed
OSEF
(2 states)
Non-Idempotent
(0 states)
postrm purge
OK
Failed
Non-Idempotent
(1 states)
OSEF
(0 states)

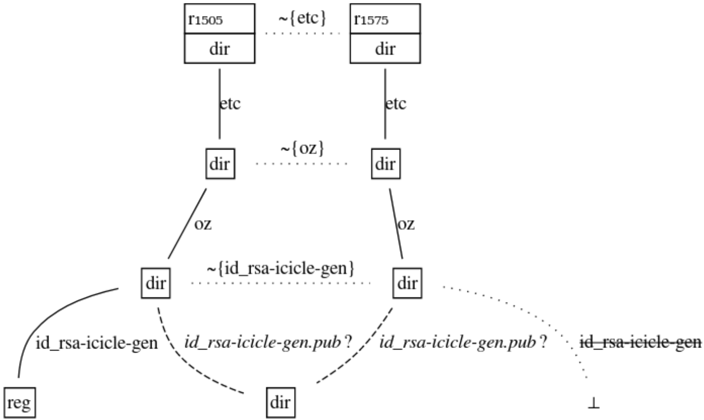
**OSEF**

0 1

**Non-Idempotent**

0

# An Execution Case

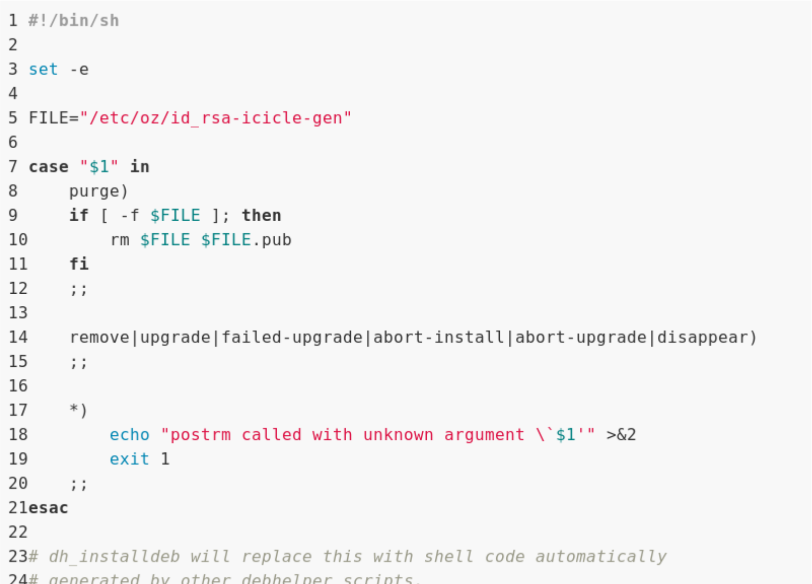


## log

```
[UTL] test 'purge' = 'purge': strings are equal
[UTL] test -f /etc/oz/id_rsa-icicle-gen: path resolves to file of type 'f'
[UTL] rm /etc/oz/id_rsa-icicle-gen: remove file
[UTL] rm /etc/oz/id_rsa-icicle-gen.pub: target does not exist or is a directory
```

# The postrm Script

## Original Shell script



```
#!/bin/sh

set -e

FILE="/etc/oz/id_rsa-icicle-gen"

case "$1" in
    purge)
    if [ -f $FILE ]; then
        rm $FILE $FILE.pub
    fi
    ;;

    remove|upgrade|failed-upgrade|abort-install|abort-upgrade|disappear)
    ;;

    *)
        echo "postrm called with unknown argument \`$1'" >&2
        exit 1
    ;;
esac

# dh_installdeb will replace this with shell code automatically
# generated by other debhelper scripts.
```

# Conclusion

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  - Webpage: http://colis.irif.fr/
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- Thank you for your attention!

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