FreeBSD package management system

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FreeBSD

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What is pkg

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- **Binary packages** management
- Replaces old `pkg_*` tools
- Uses central *sqlite3* based storage
- Provides the comprehensive toolset for **binary packages** management

Pkg development goals

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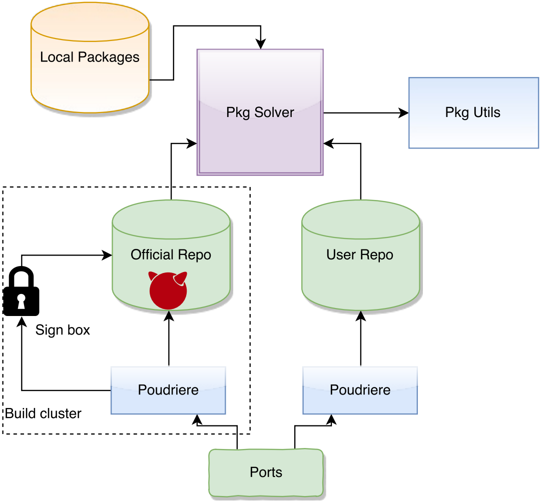
- Encourage users to install software from **binary packages**
- ...but do not prevent users from building custom packages using the **ports**

Ports management using pkg



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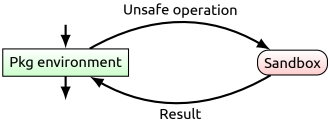

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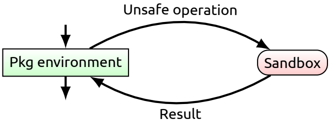

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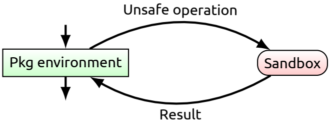

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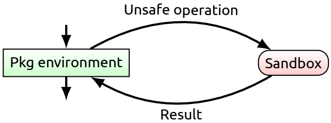

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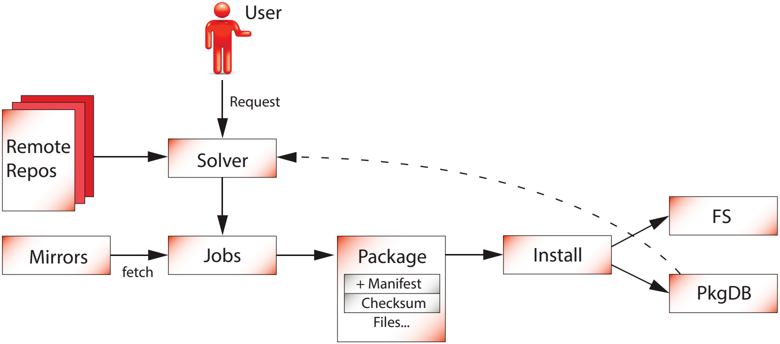
- Concurrent **locking** system

Pkg architecture



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- Ports renaming:
  - simple: `racket-textual` → `racket-minimal`
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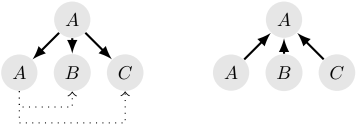

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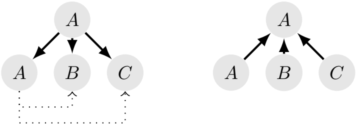

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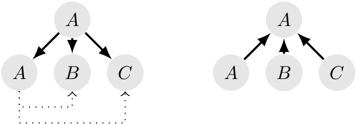

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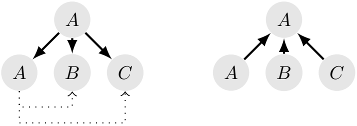

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  - adding or removing new **conflicts**

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- Set jobs priorities using the following rules:
  - install **dependencies** first
  - check for **reverse dependencies** and increase priority
  - deal with **conflicts** using the same priority
  - packages removing **reverses** the priority order

Existing systems

There are many examples of solvers used in different package management systems, for example:

- Zypper/SUSE - uses libsolv as the base
- Yum/RedHat - migrating to libsolv
- OpenBSD/pkg_add - uses internal solver
- Apt/Debian - uses internal solver
- Pacman/Archlinux - uses internal solver

External solvers

To interact with an external solver we have chosen the CUDF format used in the Mancoosi research project `http://mancoosi.org`:

```
^^Ipackage: devel/libblah
^^Iversion: 1
^^Idepends: x11/libfoo

^^Ipackage: security/blah
^^Iversion: 2
^^Idepends: devel/libblah
^^Iconflicts: security/blah-devel

^^I
```

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There are some limitations and incompatibilities with CUDF.

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- CUDF supports plain integers as versions and we need to convert versions twice
- There is no support of options in CUDF packages formulas
- External solvers are often too complicated and large

We need an internal solver!

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- Write own logic of dependencies and conflicts resolution?

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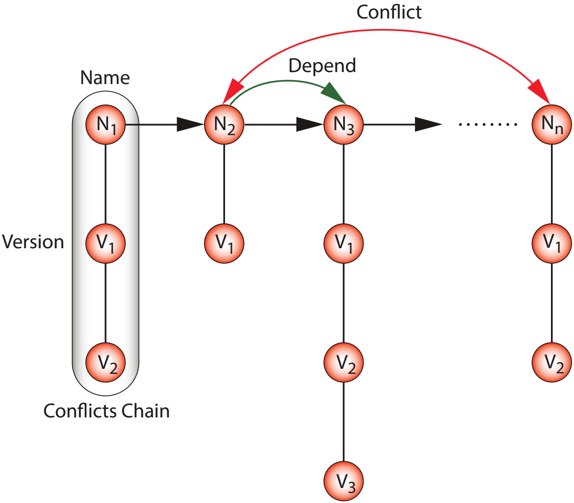
Use SAT solver for packages management

$$\overbrace{\underbrace{(x_1 \| \neg x_2 \| x_3)}_{\text{Clause}} \& (x_3 \| \neg x_1) \& (x_2)}^{\text{SAT expression}}$$

Packages universe

We convert all packages involved to a packages universe of the following structure:



Making a SAT problem

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- Convert dependencies and conflicts to **disjuncted clauses**

Converting dependencies and conflicts

- If package A depends on package B (versions B_1 and B_2), then we can either have package A not installed or any of B installed:

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- If package A depends on package B (versions B_1 and B_2), then we can either have package A not installed or any of B installed:

$$(\neg A \| B_1 \| B_2)$$

- If we have a conflict between versions of B (B_1, B_2 and B_3) then we ensure that merely one version is installed:

$$\underbrace{(\neg B_1 \| \neg B_2) \& (\neg B_1 \| \neg B_3) \& (\neg B_2 \| \neg B_3)}_{\text{Conflicts chain}}$$

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Some rules to follow to speed up SAT problem solving.

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- Trivial propagation - solve **unary** clauses
- **Unit propagation** - solve clauses with only a single unsolved variable
- **DPLL** algorithm backtracking (conflict driven resolution is used now)
- **Package specific** assumptions.

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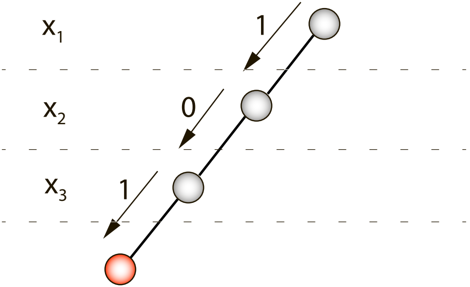
- Unit propagation - simple depends and conflicts

$$\underbrace{\overbrace{(\neg A \| B)}^{\text{Dependency}}}_{B \to \text{true}} \& \overbrace{(A)}^{\text{true}} \& \overbrace{(\neg C)}^{\text{false}} \& \underbrace{\overbrace{(\neg A \| \neg D)}^{\text{Conflict}}}_{D \to \text{false}}$$

DPLL algorithm

DPLL is proved to be one of the efficient algorithms to solve SAT problem (not the fastest but more simple than alternatives).



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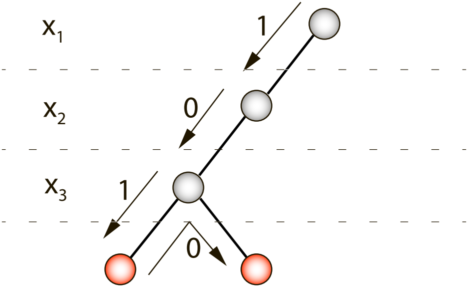

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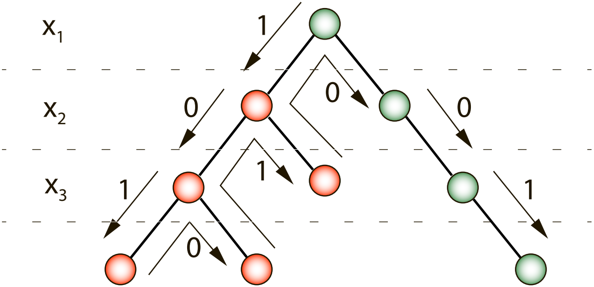

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- Additional logic when dealing with **multi-repo**

Solvers and Pkg

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- Alternatively the internal SAT solver may be used:
  - convert the universe to **SAT** problem
  - formulate request
  - ???
  - **PROFIT**

New dependencies formulae

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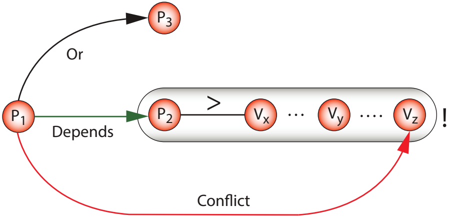

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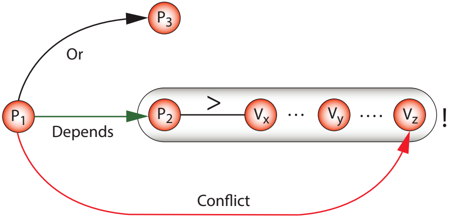

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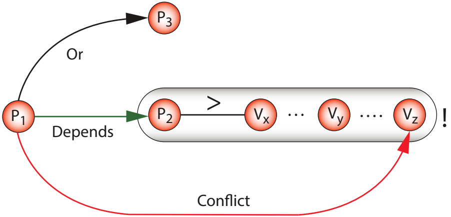

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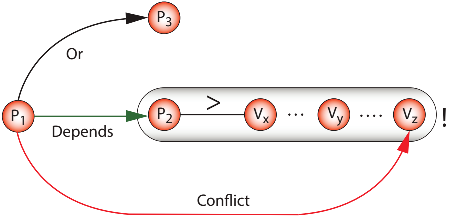

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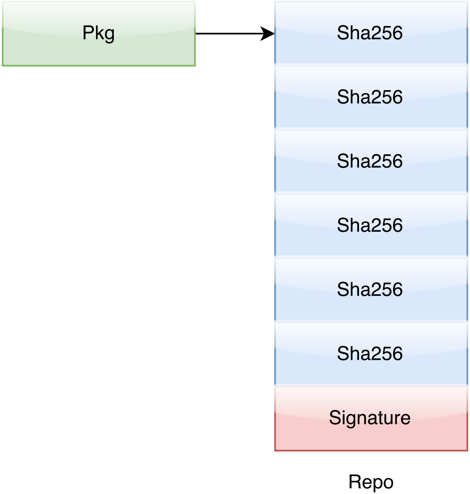
- Metadata is compressed together with payload (**slow index**)

Signatures now



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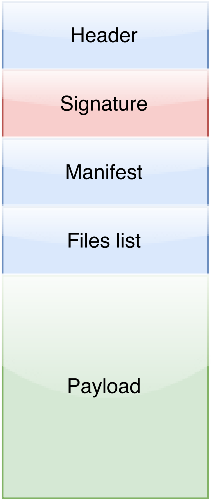

Ed25519 via asignify

For faster index

Plain tar + zstd compression

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- No direct support of libarchive (yet)

Questions?

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