FreeBSD package management system

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Pkg development goals

The main goal of pkg is to simplify system management tasks.

- Easy install, remove and upgrade of binary packages
- Integration with the ports
- Automatic resolving of dependencies and conflicts
- Provide secure package management tool

Ports and packages

Goals for pkg development.

- Ports are used to build packages
- Dependencies are resolved by pkg, not make
- Stable branch of ports has an appropriate stable branch of packages
- Encourage users to install software from binary packages

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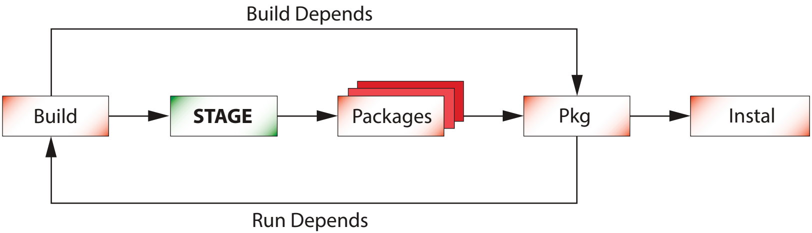
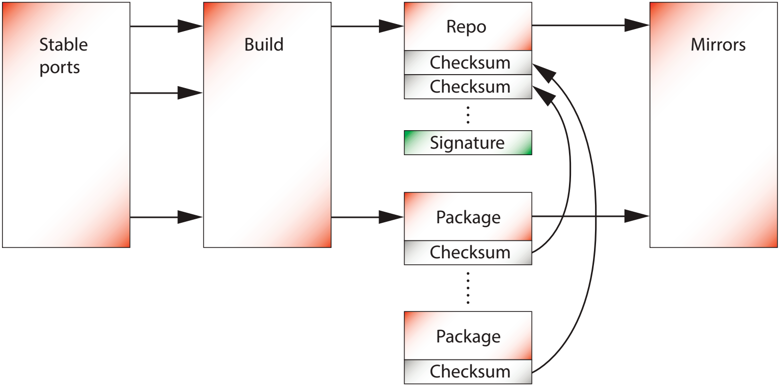
- Ports are used to build packages
- Dependencies are resolved by pkg, not make
- Stable branch of ports has an appropriate stable branch of packages
- Encourage users to install software from binary packages
- ... but do not prevent users from building custom packages using the ports

Planned ports and pkg interaction

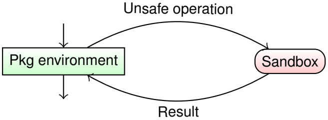


Repositories creation



What is new in pkg 1.3

- New solver that can automatically resolve complex upgrade or install scenarios
- Improved security by sandboxing untrusted operations:

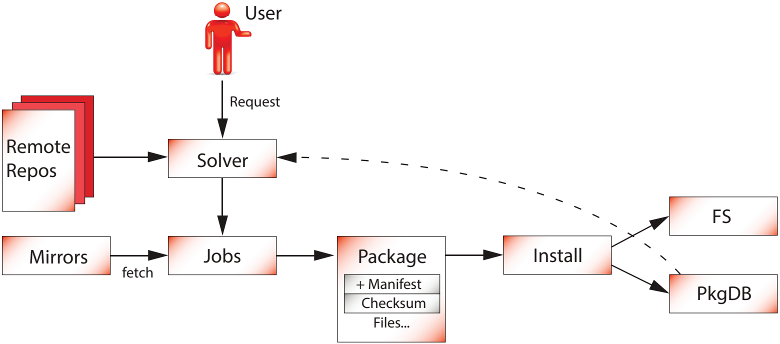


Sandboxing:

- archives extracting
- vulnxml parsing
- repositories signatures checking and public keys extracting

- Concurrent locking system

Pkg architecture

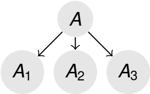


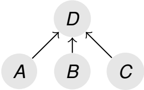
The problems of the solver in pkg

- Absence of conflicts resolving/handling
- No alternatives support
- Can perform merely a single task: install, upgrade or remove, so install task cannot remove packages for example

Tasks to solve

- Ports renaming:
  - simple: `racket-textual` → `racket-minimal`
  - splitting/merging:





- Ports reorganising:
  - files moving
  - dependencies change
  - adding or removing new conflicts

Tasks to solve

There are another issues to be resolved:

- Find conflicts using files list
- 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
- `Apt/Debian` - uses internal solver
- `Pacman/Archlinux` - uses naive internal solver

External solvers

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

```
package: devel/libblah
version: 1
depends: x11/libfoo

package: security/blah
version: 2
depends: devel/libblah
conflicts: security/blah-devel
```

Interaction with external solver

There are some limitations and incompatibilities with CUDF.

- 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
- CUDF transformation is expensive in terms of performance

We need an internal solver!

Alternatives:

- Write own logic of dependencies and conflicts resolution?

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Use SAT solver for packages management

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

Making a SAT problem

- Assign a variable to each package: package A $\rightarrow a_1$, package B $\rightarrow b_1$
- Interpret a request as a set of unary clauses:
  - Install/Upgrade package A $\rightarrow (a_1)$
  - Delete package B $\rightarrow (\neg b_1)$
- 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:

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

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:

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

- 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:

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

The solving of SAT problem

Some rules to follow to speed up SAT problem solving.

- Trivial propagation - solve unary clauses
- Unit propagation - solve clauses with only a single unsolved variable
- DPLL algorithm backtracking.
- Package specific assumptions.

SAT problem propagation

- Trivial propagation - direct install or delete rules

$$(\neg A \| B) \& \underbrace{(A)}_{true} \& \underbrace{(\neg C)}_{false} \& (\neg A \| \neg D)$$

SAT problem propagation

- Trivial propagation - direct install or delete rules

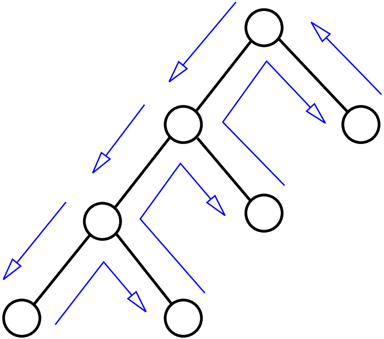
$$(\neg A || B) \& \underbrace{(A)}_{true} \& \underbrace{(\neg C)}_{false} \& (\neg A || \neg D)$$

- Unit propagation - simple depends and conflicts

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

DPLL algorithm

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



Package specific assumptions

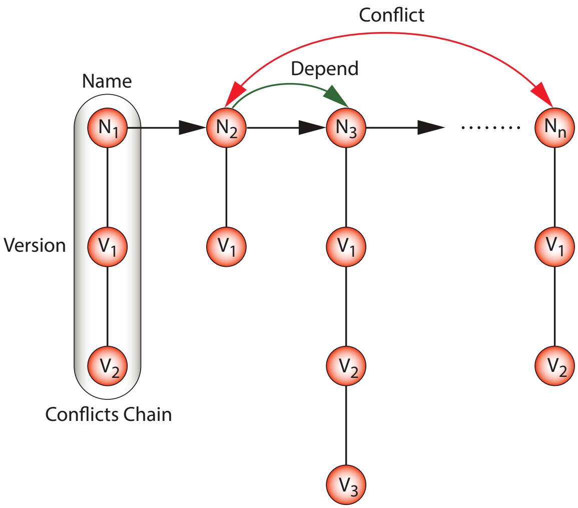
Pure SAT solvers cannot deal with package management as they do not consider several packages peculiarities:

- try to keep installed packages (if no direct conflicts)
- do not install packages if they are not needed (but try to upgrade if a user has requested upgrade)
- prefer high priority packages and repositories over low priority ones

These options also improve SAT performance providing a good initial assignment.

Packages universe

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



Package management task

- A request is splitted to install/upgrade and delete requests which could be passed simultaneously to the solver
- A conflicts between packages are detected with a repository creation
- All depends, reverse and conflicts of the requested packages are analyzed and the package universe is created
- Each package is defined by its name and the digest of significant fields (version, options and so on)

Solvers and Pkg

- Pkg may pass the formed universe to an external CUDF solver:
  - convert versions
  - format request
  - parse output
- Alternatively the internal SAT solver may be used:
  - convert the universe to SAT problem
  - formulate request
  - ???
  - PROFIT

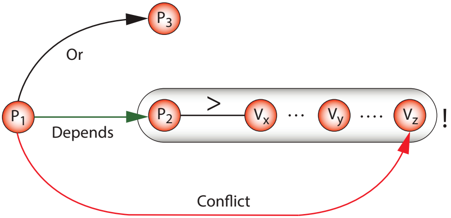
Perspectives

- Using pkg solver for ports management
- Better support of multiple repositories
- Test different solvers algorithms using CUDF
- New dependencies and conflicts format
- Provides and alternatives

New dependencies format

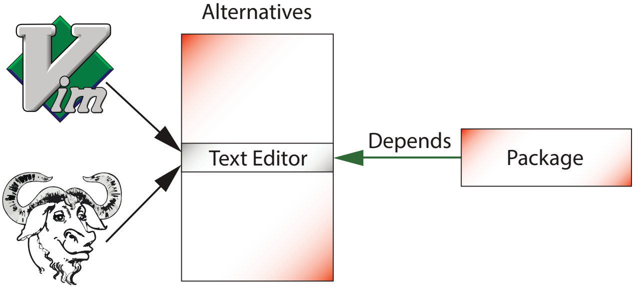
$$libblah >= 1.0 + option_1, +option_2 \| libfoo! = 1.1$$

- Can depend on normal packages and virtual packages (provides)
- Easy to define the concrete dependency versions
- Alternative dependencies



Alternatives

- Used to organize packages with the same functionality (e.g. web-browser)
- May be used to implement virtual dependencies (provides/requires)



Thank you for your attention!

Questions?

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