

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

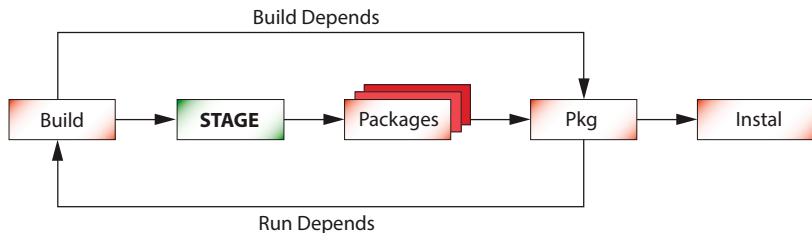
Ports and packages

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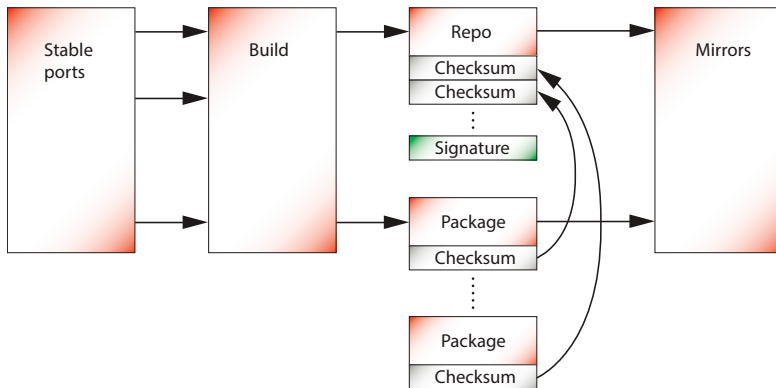
- ▶ Ports are used to build packages
- ▶ Dependencies are resolved by pkg, not make
- ▶ Stable branch of ports has an appropriate stable branch of packages
- ▶ Encourage users to install software from binary packages
- ▶ ... but do not prevent users from building custom packages using the ports



Planned ports and pkg interaction

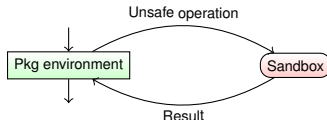


Repositories creation



What is new in pkg 1.3

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

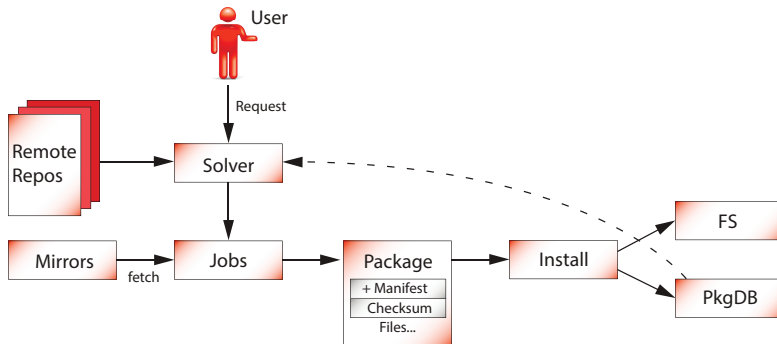


Sandboxing:

- ▶ archives extracting
- ▶ vulnxml parsing
- ▶ repositories signatures checking and public keys extracting
- ▶ Concurrent locking system



Pkg architecture



The problems of the solver in pkg

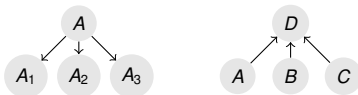
- ▶ Absence of conflicts resolving/handling
- ▶ No alternatives support
- ▶ Can perform merely a single task: install, upgrade or remove, so install task cannot remove packages for example



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 some existing solution?

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- ▶ Use some known algorithm?

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Use SAT solver for packages management

$$\overbrace{(x_1 \parallel \neg x_2 \parallel x_3) \& (x_3 \parallel \neg x_1) \& (x_2)}^{\text{SAT expression}}$$

Clause

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:

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

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:

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

- ▶ 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:

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

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

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

SAT problem propagation

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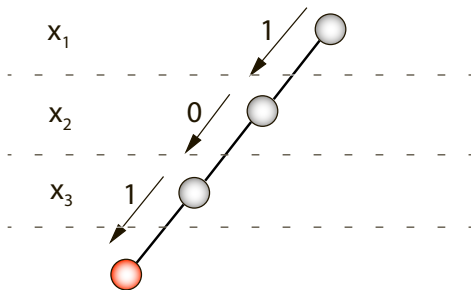
- ▶ Unit propagation - simple depends and conflicts

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

$B \rightarrow true$ $D \rightarrow false$

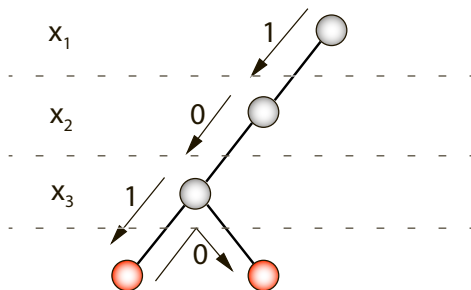
DPLL algorithm

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



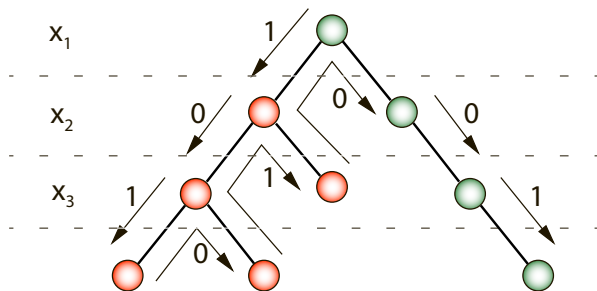
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Package specific assumptions

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

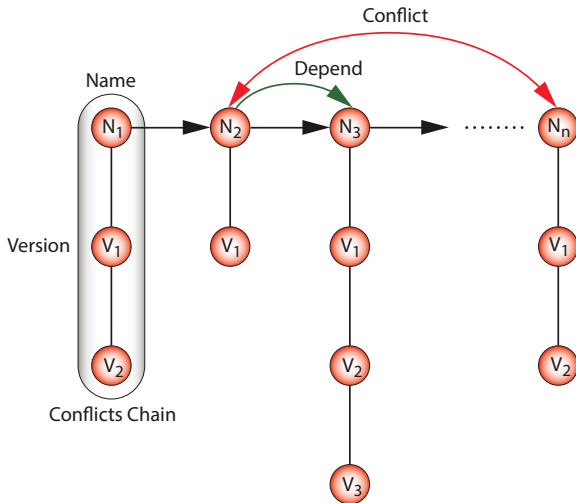
- ▶ try to keep installed packages (if no direct conflicts)
- ▶ do not install packages if they are not needed (but try to upgrade if a user has requested upgrade)
- ▶ prefer high priority packages and repositories over low priority ones

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:



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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

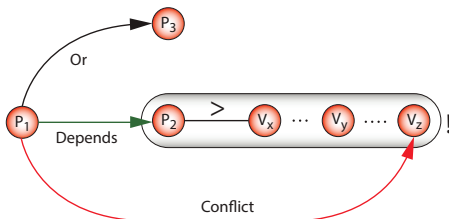
- ▶ Using pkg solver for ports management
- ▶ Better support of multiple repositories
- ▶ Test different solvers algorithms using CUDF
- ▶ New dependencies and conflicts format
- ▶ Provides and alternatives



New dependencies format

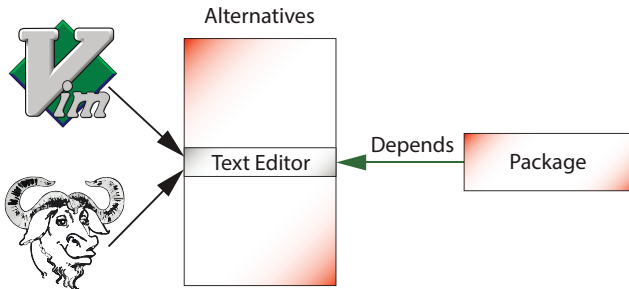
libblah $\geq 1.0 + option_1, + option_2 || libfoo! = 1.1$

- ▶ 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)





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Thank you for your attention!
Questions?

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