FreeBSD package management system

Vsevolod Stakhov
vsevolod@FreeBSD.org

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What is pkg

Pkg (previously pkgng) is the binary package management system written for FreeBSD.

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

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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
- Encourage users to install software from binary packages

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- Easy install, remove and upgrade of binary packages
- Integration with the ports
- Automatic resolving of dependencies and conflicts
- Provide secure package management tool
- Encourage users to install software from binary packages
- . . . but do not prevent users from building custom packages using the ports

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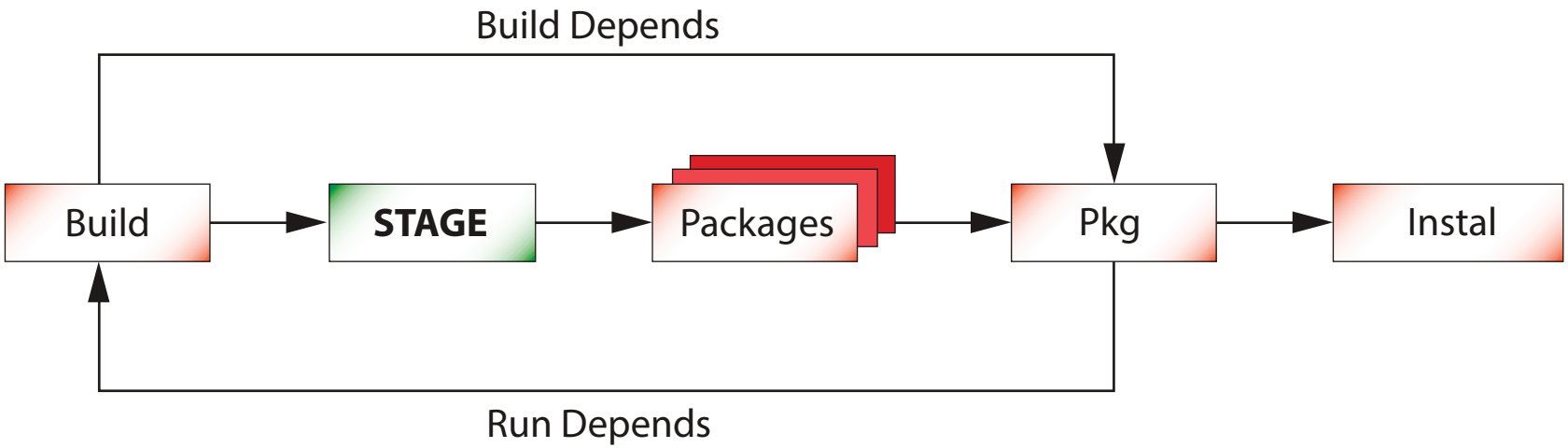
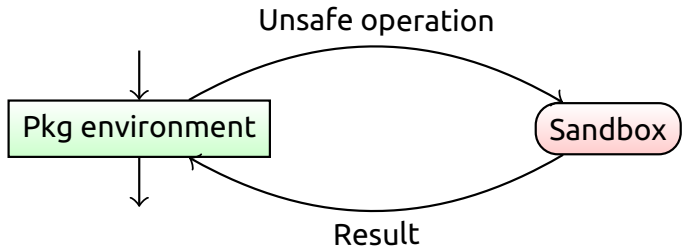
Planned ports and pkg interaction



What is new in pkg 1.3

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

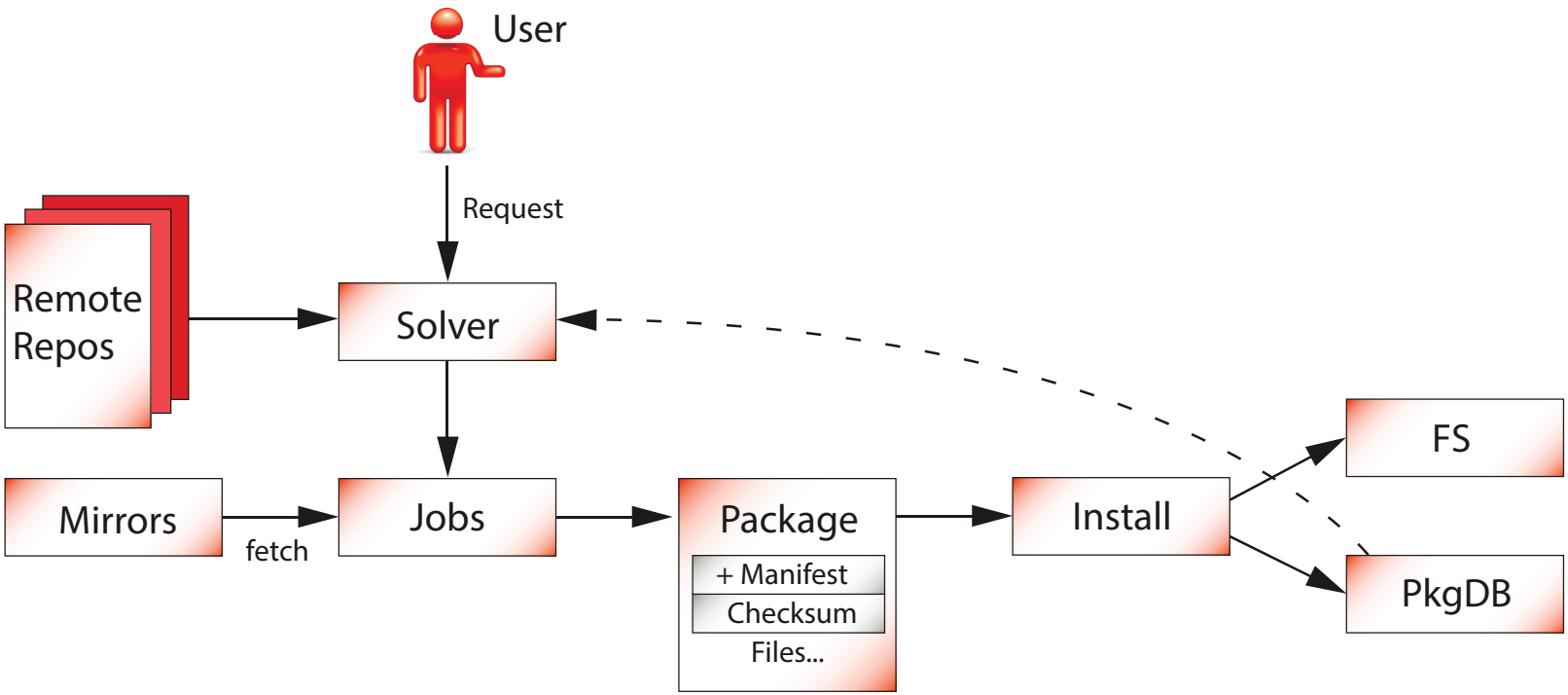


Sandboxing:

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

- Concurrent locking system

Pkg architecture

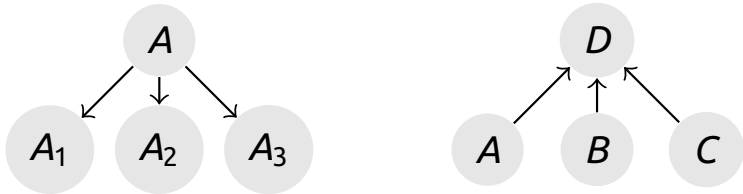


The problems of the old solver in pkg

- Absence of conflicts resolving
- No alternatives support (plain dependencies only)
- Can perform merely a single task: either install or upgrade or remove

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:

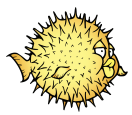
- Find conflicts using files list
- Set jobs priorities using the following rules:
  - install dependencies first
  - check for reverse dependencies and increase priority
  - deal with conflicts using the same priority
  - packages removing reverses the priority order

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
- 
`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`:

```
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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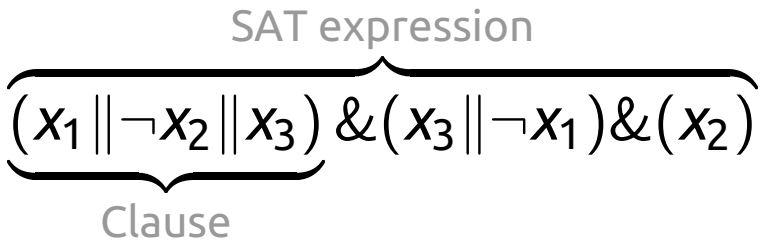
Use SAT solver for packages management



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.

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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

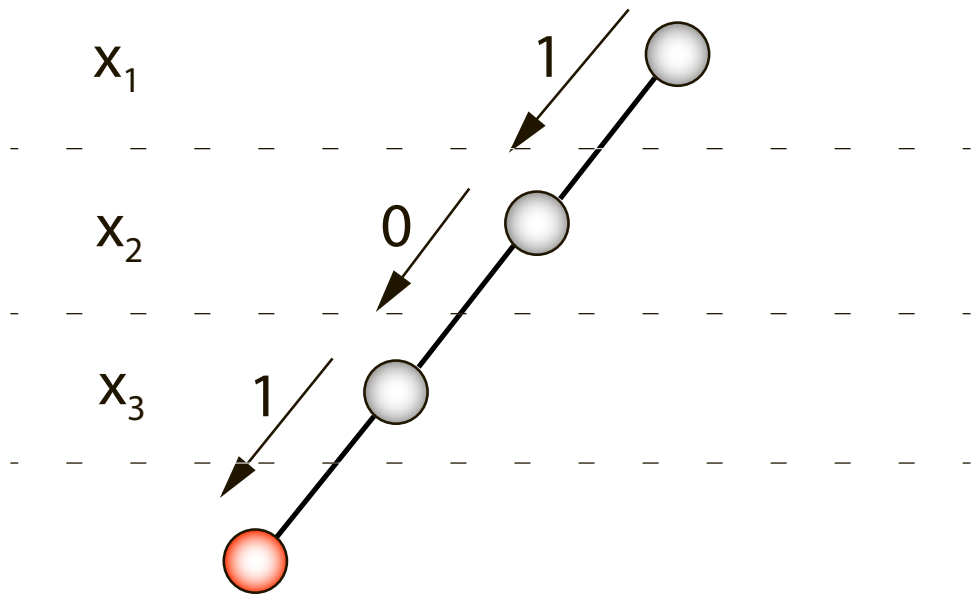
$$(\neg A \| B) \& \underbrace{(A)}_{true} \& \underbrace{(\neg C)}_{false} \& (\neg A \| \neg D)$$

- Unit propagation - simple depends and conflicts

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

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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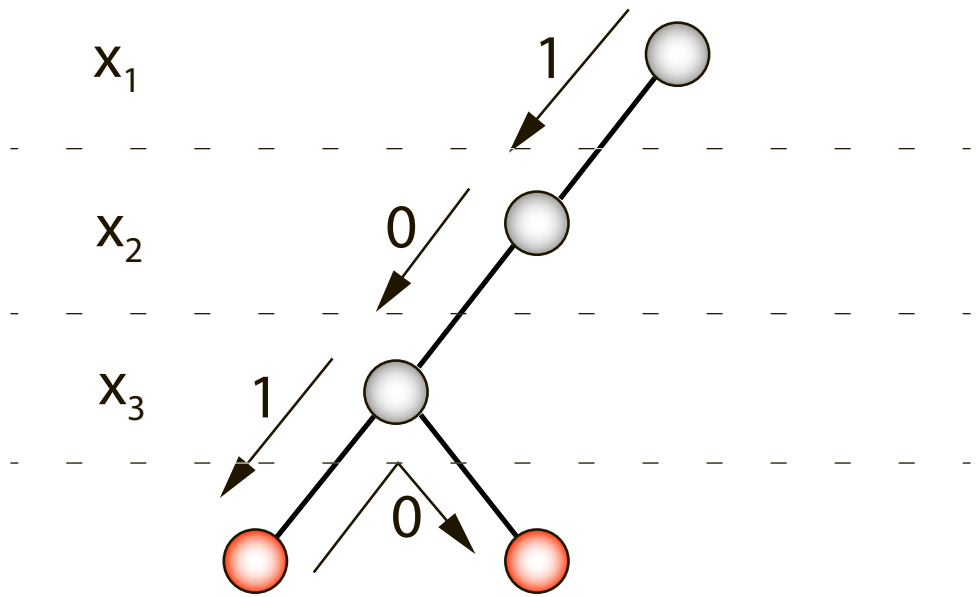

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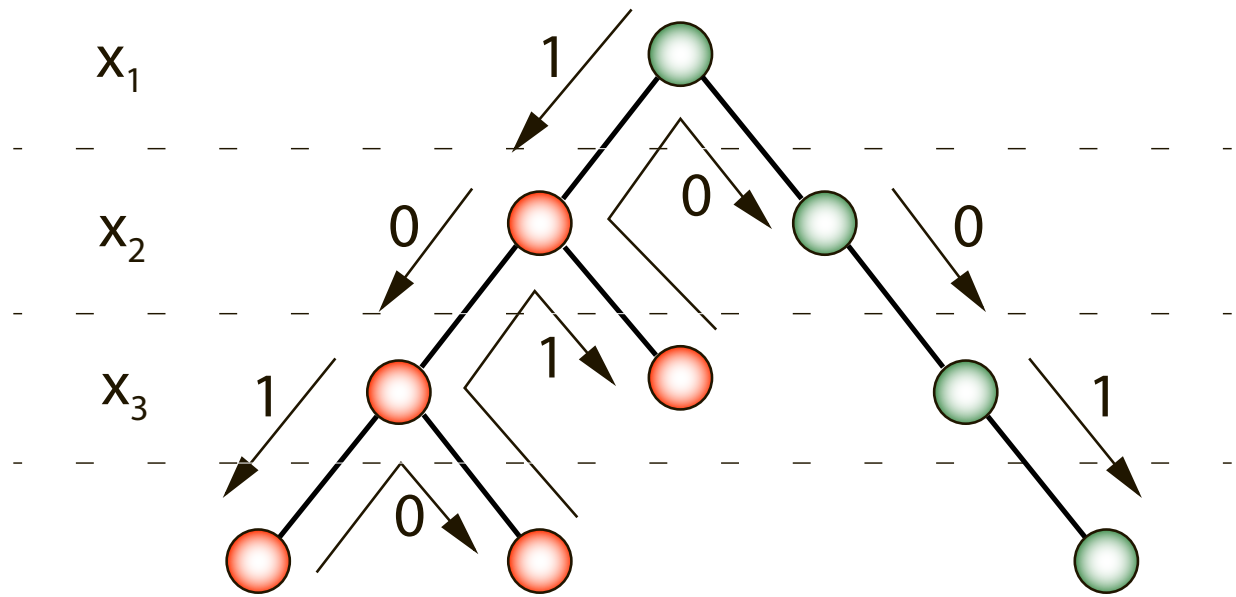


Package specific assumptions

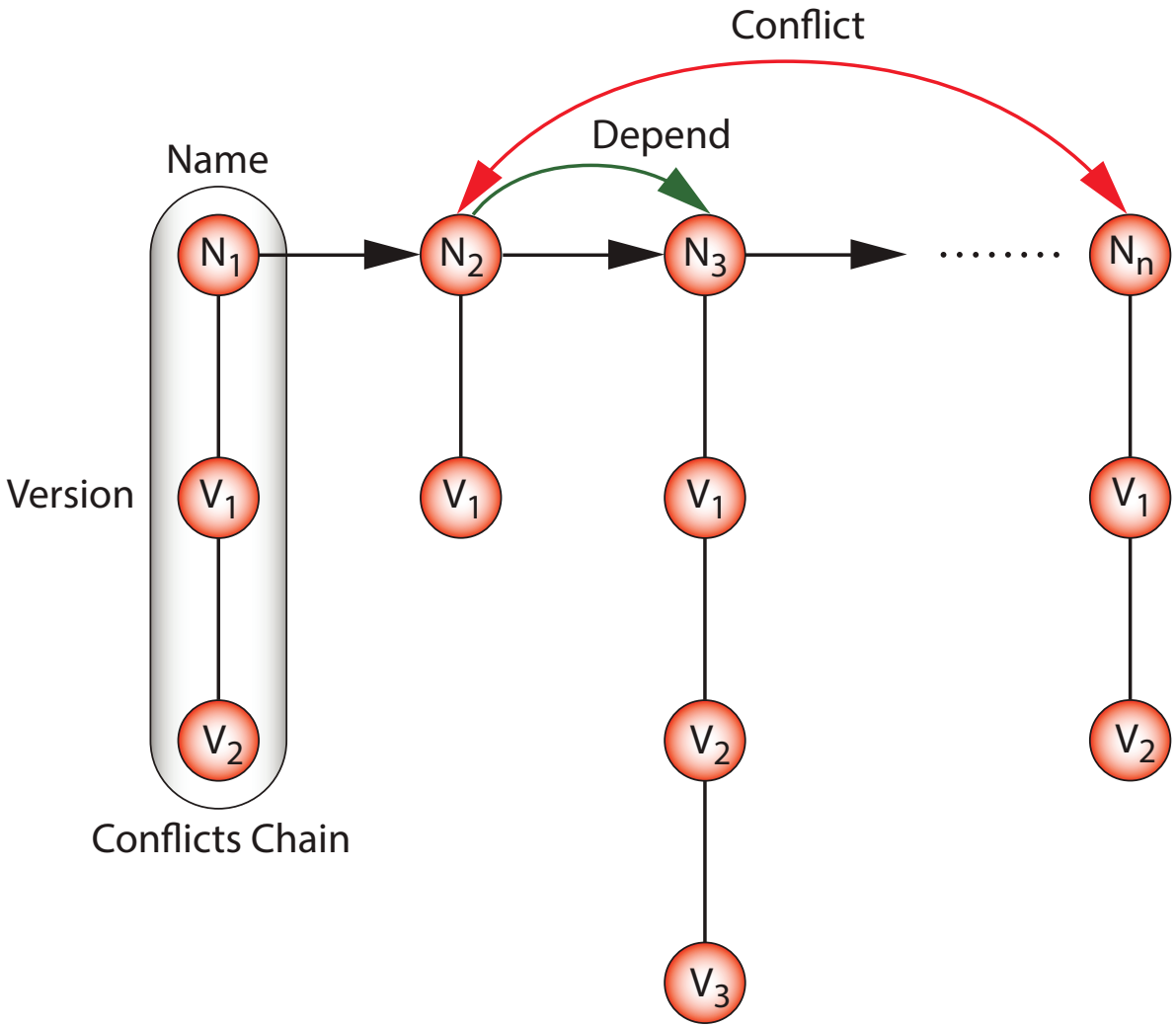
Pure SAT solvers cannot deal with package management as they do not consider several packages peculiarities:

- 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)

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

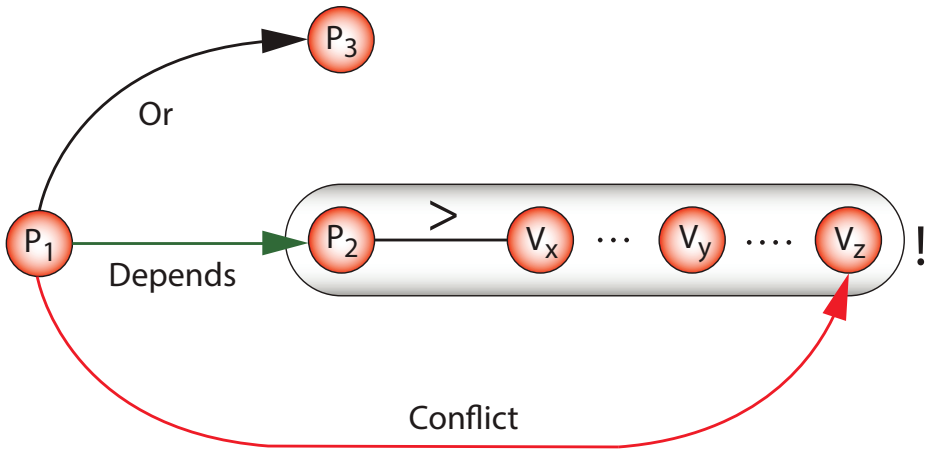
Perspectives

- 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

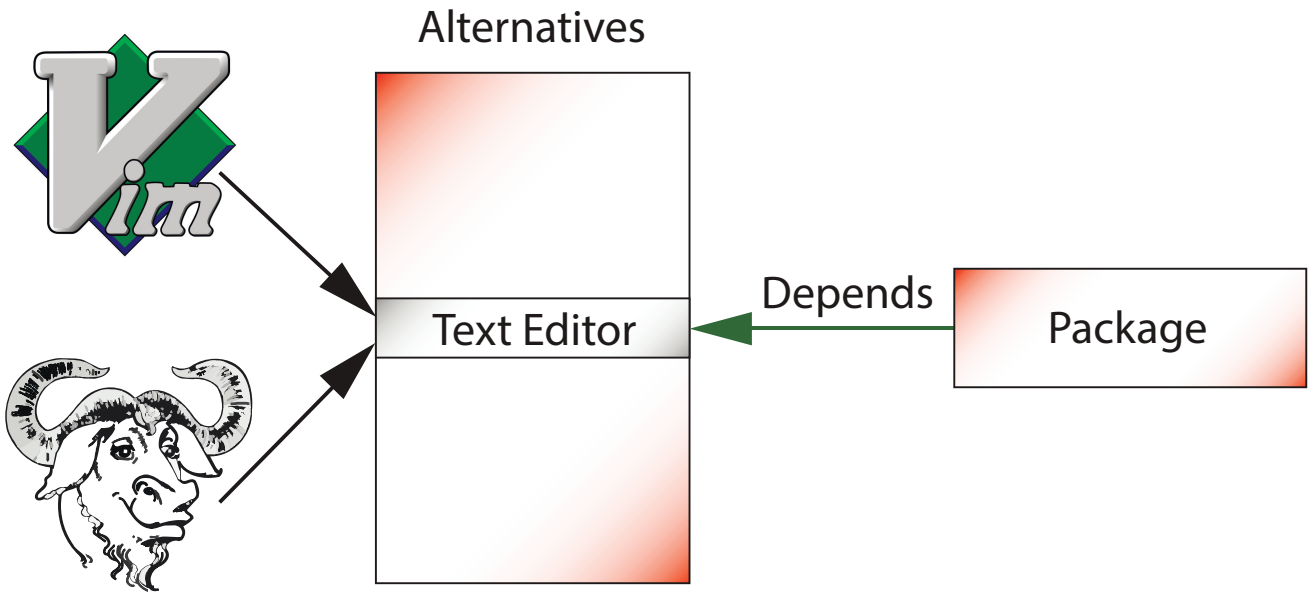
$$libblah >= 1.0 + option_1, +option_2 || libfoo! = 1.1$$

- 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)



Existing issues to be solved prior to 1.3

- A solver cannot find install candidates for non-automatic top level packages (those without reverse depends)
- Package upgrade is performed improperly (need to rename, install and unlink)
- Minor issues and crashes

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Thank you for your attention!

Questions?

vsevolod@FreeBSD.org

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