FreeBSD package management system

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Ports and packages

Ports is the comprehensive system of source packages.

- Mature
- Clear and well defined
- Simple (sometimes not)
- Configurable

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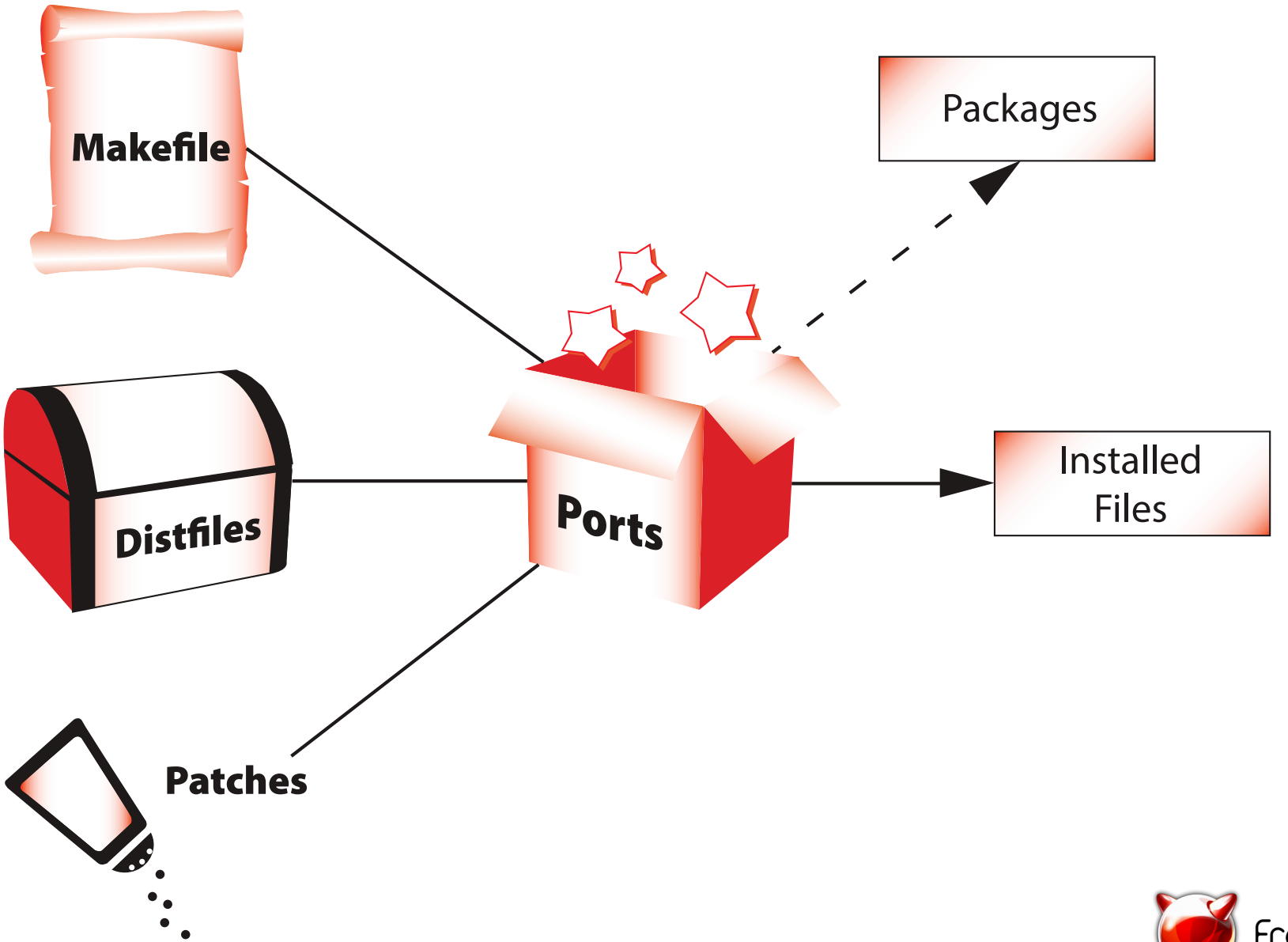
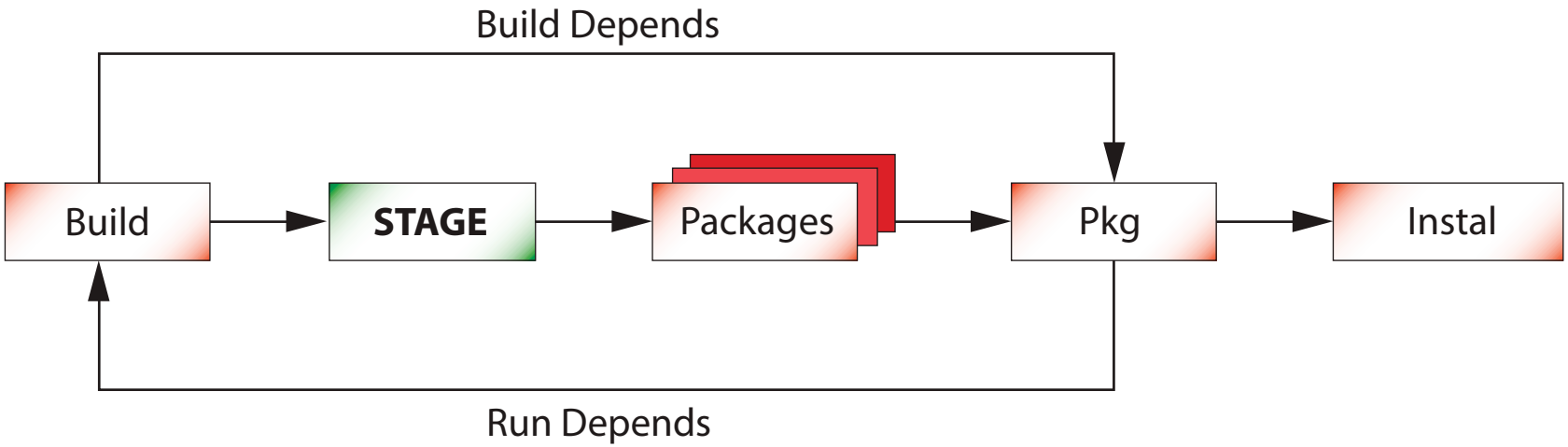
Ports before pkg



Disadvantages of the old architecture

- Make cannot handle complex packages relationships
- Complicated upgrade procedure (hard to keep up-to-date)
- Hard to migrate between releases
- Long build time

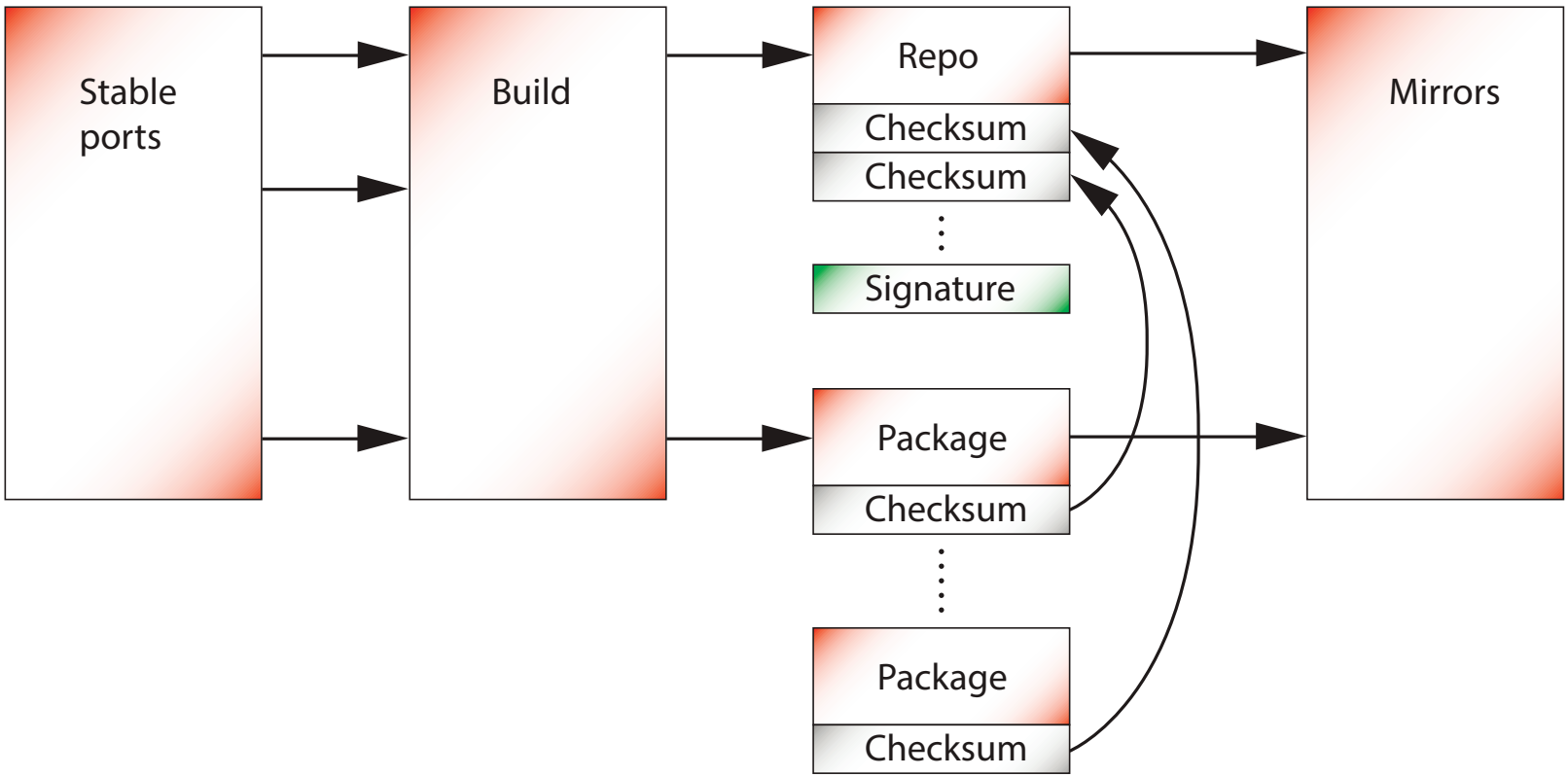
Planned ports and pkg interaction



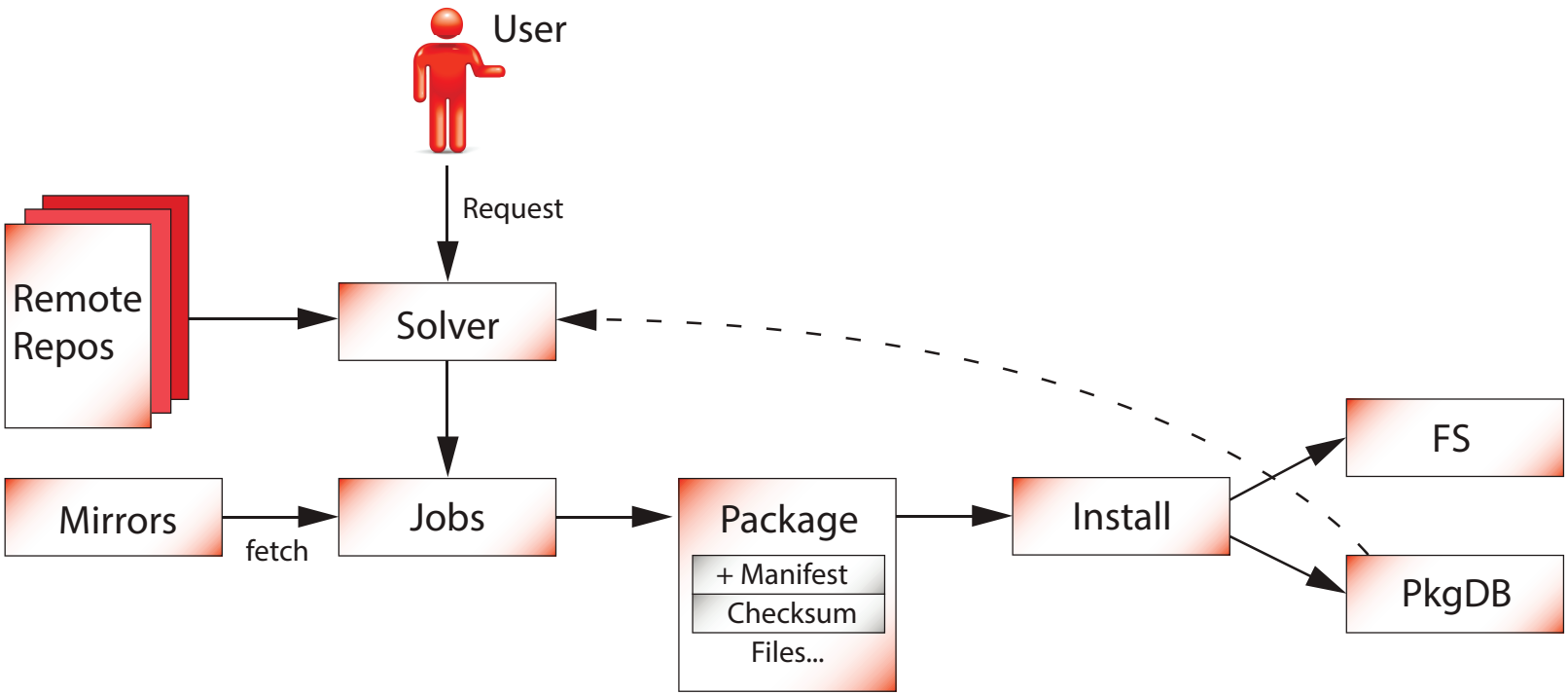
Ports and packages

- 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 them from building custom packages from the ports

Repositories creation



Pkg architecture



The current problems with pkg

- Legacy ports support (with no staging, for example)
- Plain dependencies style
- Naive solver

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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

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
```

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

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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
- Conflicts learning - if we assign some free variable and detect a conflict during unit propagation, we can fallback and learn that this variable must be negated
- 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

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

Conflicts driven learning

To handle alternatives it is required to test all variables unassigned:

1. full depth-first enumeration of possible values
2. fallback if a conflict found
3. remember which assignment caused conflict
4. make negative assignment for the learned variable and go to the first step

Package specific assumptions

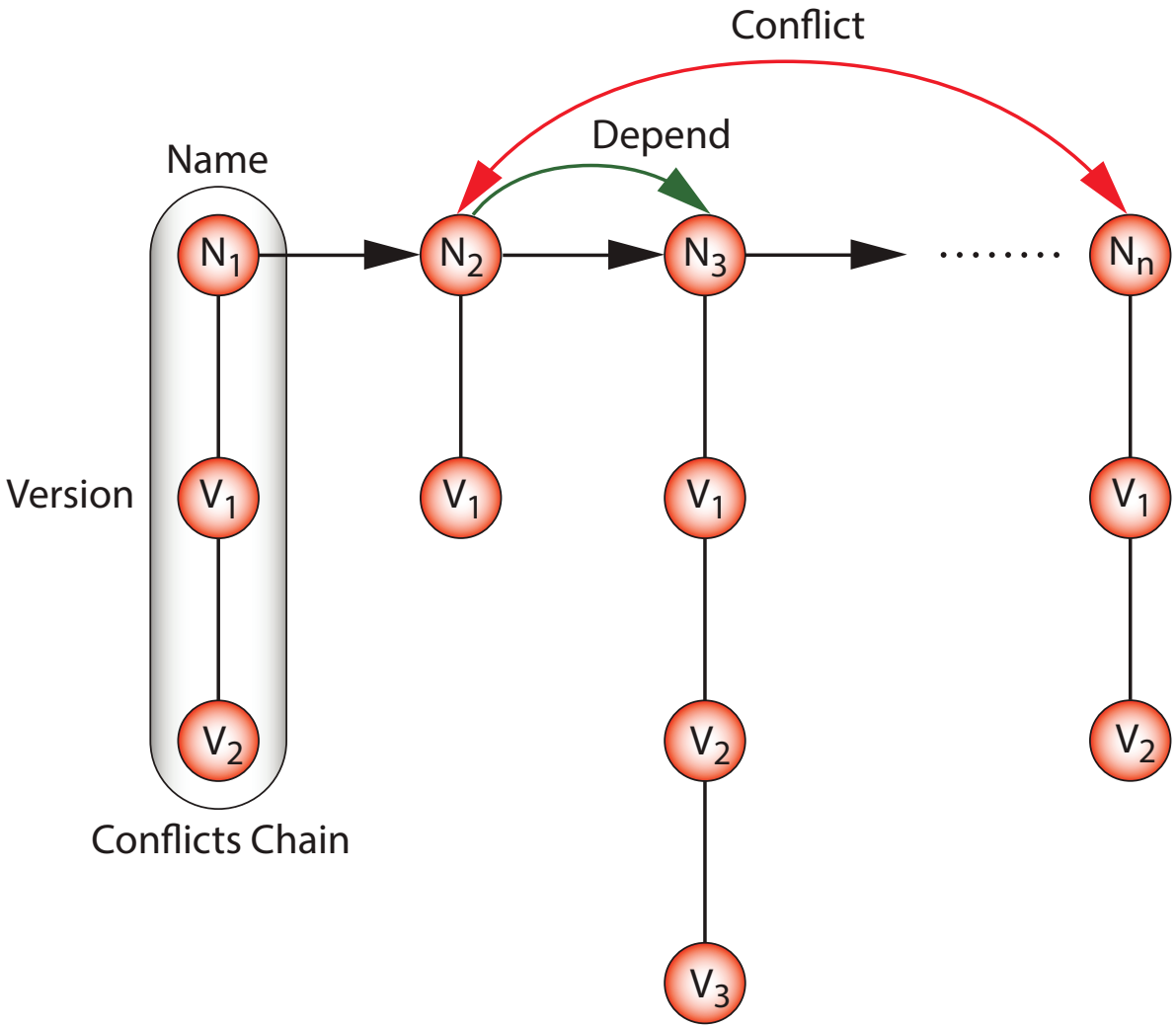
Pure SAT solvers cannot deal with package management as they do not consider several packages peculiarities:

- try to keep installed packages (if no direct conflicts)
- do not install packages if they are not needed
- 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

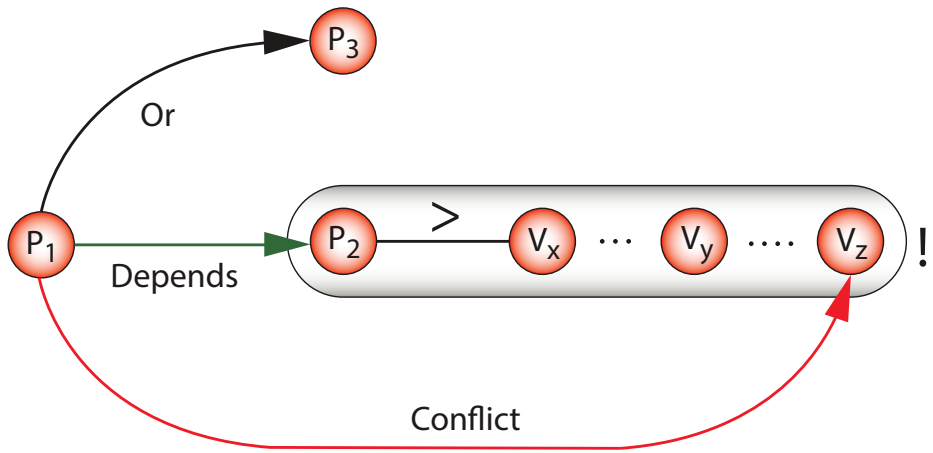
Perspectives

- 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

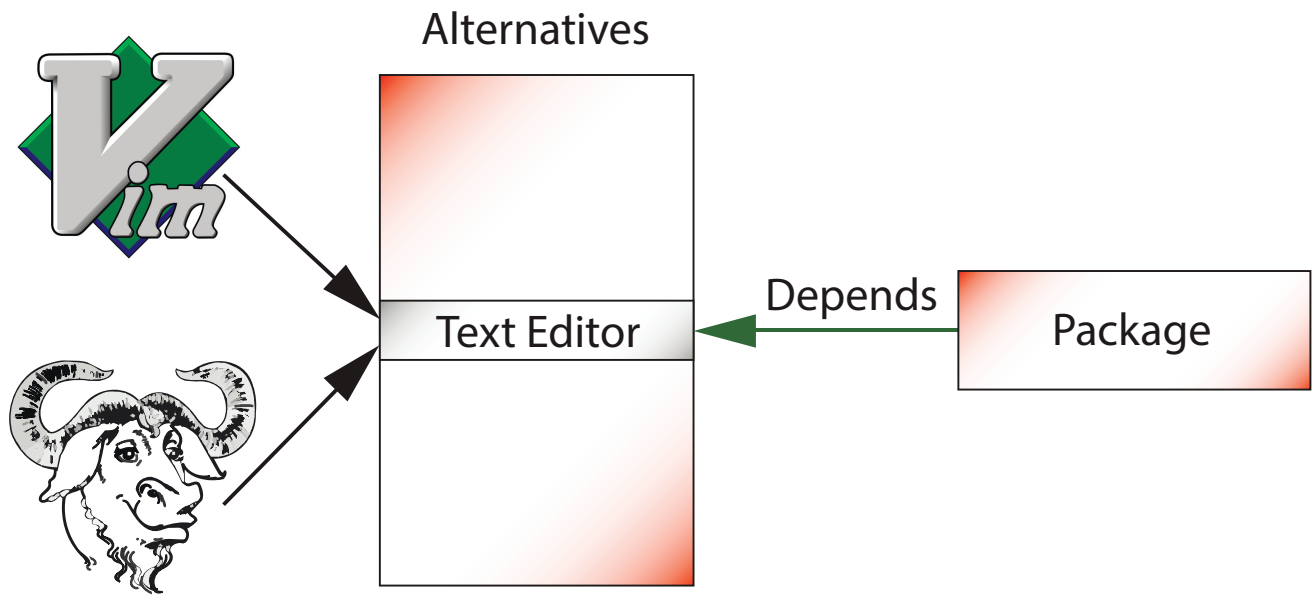
$$libblah >= 1.0 + option_1, +option_2 || libfoo! = 1.1$$

- 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)



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Thank you for your attention!

Questions?

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