Bits for the Mancoosi project

yeah, including "visualizing package clusters" :-)

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Outline

1. Past
   - The EDOS project
   - Package dependencies: the formal way
2. Present
   - QA tools
   - The Mancoosi project
   - Fun with the Debian dependency graph
3. Future

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The EDOS project [http://www.edos-project.org]

name *Environment for the development and Distribution of Open Source software*

funding European Commission, IST activities 6th framework programme

timeframe October 2004 – June 2007

consortium universities (Paris 7, Tel Aviv, Zurich, Geneva), research institutions (INRIA), companies (Caixa Magica, Nexedi, Edge-IT (i.e. Mandriva), CSP Torino)

objective *study and solve problems associated with the production, management and distribution of open source software packages*

Debian: not officially involved, but 1 DD (Ralf Treinen) was involved. A lot of code has been integrated into Debian and is being used daily for QA purposes.

EDOS Workpackages

EDOS was relatively broad in scope, split into several workpackages:

1. formal management of software dependencies
2. flexible testing framework
3. peer-to-peer content dissemination system
4. metrics and evaluation

Focus: distribution coherence from release manager's point of view

Main question

> *Is it possible, for a given user selection of packages, to install them when only the packages from a given repository are available?*

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What is an inter-package relationships?

First EDOS objective: establish a simple mathematical model of a distribution. Design decision: do so by looking at inter-package relationships.

```
Package: aterm
Depends: libc6 (>= 2.3.2.ds1-4), libice6 | xlibs (» 4.1.0), ..
```

to be interpreted as a propositional logic formula in CNF having (versioned) package names as literals, i.e.

$$\texttt{libc6} \wedge (\texttt{libice6} \vee \texttt{xlibs}) \wedge \ldots$$

... some care is required though:

- *multiple versions*: foo becomes $\text{foo}_{1.0} \mid \text{foo}_{1.1} \mid \ldots$
- *virtual packages*: `m-t-a` becomes `postfix` | `exim` | `sendmail` | ...

What is a repository then?

Putting it all together, a distribution repository is modeled as:

1. a set of (versioned) *packages P*
2. a function *D* associating packages to *dependencies* (formulae)
3. a set of *conflicts C*, i.e. pairs of non co-installable packages

Example (modeling of the previously shown Packages)

$$\begin{aligned}
P &= \{(a,1),(b,2),(b,3),(c,3),(d,1),(d,2),(d,3)\} \\
D(a,1) &= \{\{(b,2),(b,3)\},\{(c,3),(d,2),(d,3)\}\} \\
D(b,2) &= \emptyset \\
&\ldots \\
C &= \{((b,2),(b,3)),((b,3),(b,2)),((c,3),(b,2)),\ldots\}
\end{aligned}$$

Package installability as SAT

The problem of whether a package is installable in a given repository is equivalent to SAT:[1]

- each *package p* with version *v* is a *boolean variable* p_v
  - `if` p_v then the package should be installed `else` it should not
- each *dependency* is a logical *implication*, e.g.: `aterm` $\rightarrow$ `libc6` $\wedge$ (`libice6` $\vee$ `xlibs`) $\wedge$ `...`
- each *conflict* between *a* and *b* is a formula $\neg(a \wedge b)$

Theorem

A package p (with version v) is installable iff there exist a boolean assignment that makes p_v true, and satisfies the encoding of the repository.

(Not so) nice consequence: package installability is a *hard* problem.

[1] deciding whether a formula in propositional logic is satisfiable or not

Package installability as SAT — example

`apt-get install libc6=2.3.2.ds1-22`

in

```
Package: libc6
Version: 2.2.5-11.8

Package: libc6
Version: 2.3.5-3

Package: libc6
Version: 2.3.2.ds1-22
Depends: libdb1-compat

Package: libdb1-compat
Version: 2.1.3-8
Depends: libc6 (>= 2.3.5-1)

Package: libdb1-compat
Version: 2.1.3-7
Depends: libc6 (>= 2.2.5-13)
```

becomes

$$
\begin{aligned}
& l^{2.3.2.ds1-22}_{\texttt{libc6}} \\
& \wedge \\
& \neg(l^{2.3.2.ds1-22}_{\texttt{libc6}} \wedge l^{2.2.5-11.8}_{\texttt{libc6}}) \\
& \wedge \\
& \neg(l^{2.3.2.ds1-22}_{\texttt{libc6}} \wedge l^{2.3.5-3}_{\texttt{libc6}}) \\
& \wedge \\
& \neg(l^{2.3.5-3}_{\texttt{libc6}} \wedge l^{2.2.5-11.8}_{\texttt{libc6}}) \\
& \wedge \\
& \neg(l^{2.1.3-7}_{\texttt{libdb1-compat}} \wedge l^{2.1.3-8}_{\texttt{libdb1-compat}}) \\
& \wedge \\
& l^{2.3.2.ds1-22}_{\texttt{libc6}} \rightarrow \\
& (l^{2.1.3-7}_{\texttt{libdb1-compat}} \vee l^{2.1.3-8}_{\texttt{libdb1-compat}}) \\
& \wedge \\
& l^{2.1.3-7}_{\texttt{libdb1-compat}} \rightarrow \\
& (l^{2.3.2.ds1-22}_{\texttt{libc6}} \vee l^{2.3.5-3}_{\texttt{libc6}}) \\
& \wedge \\
& l^{2.1.3-8}_{\texttt{libdb1-compat}} \rightarrow l^{2.3.5-3}_{\texttt{libc6}}
\end{aligned}
$$

. . . average formula has 400 literals, KDE installation 32’000

Good qualities for a repository

An installation is a repository subset.
In a healthy installation: all dependencies are satisfied (*abundance*) and no pairs of conflicting packages are co-installed (*peace*)

i.e. what our package managers are meant to enforce!

A package in a repository is installable if there exists at least one healthy installation which contains it

i.e. there is at least *one way* for our users to install it

A package repository is trimmed if every package it contains is installable wrt the repository itself

i.e. there are no “broken” packages

Shipping non-trimmed repositories = shipping packages that users will not be able to install

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Quality Assurance

On the basis of the presented formalization, several QA tools for distro have been developed:

edos-debcheck command line checker for package installability

pkglab interactive, console-based environment for repository inspection

ceve parser/converter between package list formats

tart slice a repository (e.g. media), so that packages available on the *i*-th slice are installable using only slices up to *i*

edos-debcheck

- edos-debcheck takes as input APT package list(s) and checks whether one, several, or all packages in it are installable

Customized SAT solver, *very fast*: checking installability of all package in main testing/amd64 takes 5 seconds on an entry-level machine.

Example

```
edos-debcheck </var/lib/apt/lists/..._main_binary-amd64_Packages
Parsing package file... 1.2 seconds    21617 packages
Generating constraints... 2.3 seconds
Checking packages... 1.5 seconds
acx100-source (= 20070101-3): FAILED
alien-arena (= 7.0-1): FAILED
alien-arena-browser (= 7.0-1): FAILED
alien-arena-server (= 7.0-1): FAILED
alsa-firmware-loaders (= 1.0.16-1): FAILED
amoeba (= 1.1-19): FAILED
...
# explanation can be required as well
```

Debian package: edos-debcheck

main author: *Jérôme Vouillon*

edos-debcheck noteworthy applications

- **EmDebian**: upload time check to avoid uninstallability
  - harder in Debian: long path between upload and archive
  - how about an advisory dput hook?
- **edos-builddebcheck**: wrapper around edos-buildcheck to check satisfiability of *build-dependencies* (by zack and treinen)
  - used pre-release to check buildability in the new release
  - soon(?) in wanna-build to avoid spurious errors (by nomeata)
- **uninstallable packages**, daily monitor
  http://edos.debian.net/edos-debcheck
- **undeclared Conflicts**, periodic monitor (by treinen)
  http://edos.debian.net/missing-conflicts/

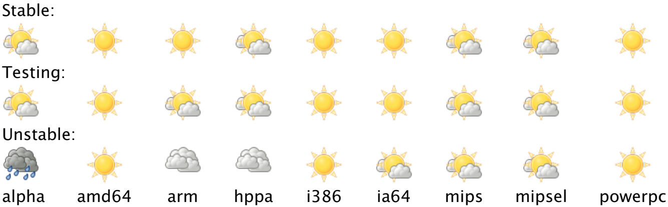
```
dpkg: error processing
/var/cache/apt/archives/gcc-avr_1%3a4.3.0-1_amd64.deb (-unpack):
trying to overwrite '/usr/lib64/libiberty.a', which is also in package binutils
```

Debian weather!

Just for fun, Debian weather (http://edos.debian.net/weather/) gives a weather-like representation of uninstallable packages statistics

The "Debian weather" for today: mostly sunny in stable and testing, at places overcast and rainy in unstable.

clear	< 1%
few clouds	1%...2%
clouds	2%...3%
showers	3%...4%
storm	> 4%



pkglab

- pkglab is an interactive, console-based environment to explore package repositories of package-based software distributions.

Features:

- load current and past package lists
- package installability checks (a-la edos-debcheck)
- functional query language (map, filter, fold, . . .)
- inspect historical evolution of repositories

Debian package: pkglab

pkglab — examples

```
(* interactive equivalent of edos-debcheck *)

> $diag <- check($unstable,$unstable)
Solver: Computing closure
Solver: Done, 22156 packages in closure
Solver: Numbering
Solver: Converting to boolean problem
Solver: Done, formula of size 200184
<diagnosis:closure size 22156, 141 failures>
> #show $diag
Diagnosis:
 Conflicts: 13997
 Disjunctions: 155280
 Dependencies: 164279
 Failures (total 141):
  Package acidlab'0.9.6b20-22@all
  cannot be installed:
   acidlab'0.9.6b20-22@all depends on one of:
    - libphp-phplot'4.4.6+5.0rc1.dfsg-0.1@all
   libphp-phplot'4.4.6+5.0rc1.dfsg-0.1@all
   depends on missing:
    - php3
    - php3-cgi
    - php4
    - php4-cli
```

```
(* same check in stable of a few months ago *)

check(acidlab'0.9.6b20-22@all,
      contents(%debian/stable/main/i386,
               2008-03-20))
(...)
<diagnosis:closure size 557, 0 failures>
```

pkglab — examples (cont.)

```
(* check co-installability of php{4,5} *)

> $d<-check_together(
         php4'6:4.4.4-8+etch4@all,
      php5'5.2.5-3@all, $a)
(...)
Solver: Not successful, 1 failures
> #show $d
Diagnosis:
 (...)
 Failures (total 1):
  Packages php5'5.2.5-3@all
       and php4'6:4.4.4-8+etch4@all
  cannot be installed together:
  php4'6:4.4.4-8+etch4@all
  depends on missing
  - libapache-mod-php4(>='6:4.4.4-8+etch4)
  - libapache2-mod-php4(>='6:4.4.4-8+etch4)
  - php4-cgi(>='6:4.4.4-8+etch4)
```

```
(* works in the union of stable and unstable *)

> check_together(php4'6:4.4.4-8+etch4@all,
                php5'5.2.5-3@all,
  $a|contents(%debian/stable/main/i386,
                2008-03-20))
(...)
<diagnosis_list:closure size 857,
 0 failures>
```

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The Mancoosi project [http://www.mancoosi.org]

Mancoosi picks up the baton from where EDOS left: the focus is now the sysadm (our *user* and her interaction with package management.

name *MANaging the COmplexity of the Open Source Infrastructure*

funding European Commission, IST activities 7th framework programme

timeframe February 2008 – January 2011

consortium universities (Paris 7, L'Aquila, Sophia Antipolis, Tel Aviv, Louvain), research institutions (INESC-ID), companies (Caixa Magica, Pixart, Edge-IT (i.e. Mandriva), ILOG)

objective develop *rollback mechanisms for package upgrades* and *better algorithms to plan package upgrade paths*

Debian is not officially involved, but 2 DDs (treinen and zack) are enrolled as researchers among the ranks of Paris 7

The upgrade problem

Upgrade problem = the “problem” posed by a user request to change the *local status* of installed packages

Solving an upgrade problem can *fail* for several reasons:

- invocation error, dependency solving, package retrieval, package unpacking, maintainer script execution, . . .

Mancoosi will try to attack the upgrade problem from two sides:

rollback support
: there are impredictable failures (e.g. maintscripts), a posteriori recovery techniques are the only way out

dependency solving
: not satisfying meta-installer state of the art (e.g. *incompleteness*: the inability to find a solution when there is one): we should to better!

while studying this ... we’ve met the Debian dependency graph

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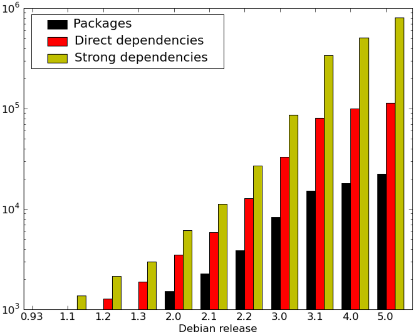
Debian dependency graph

- a node for each (binary) package
- an edge from p to q each time q appears somewhere in the (Pre)-Depends field ofr p

Debian is huge, its dependency graph is huge as well: about 25'000 nodes, 400'000 edges.

It used to grow exponentially, it is stabilizing.



All dependencies are equal but . . .

The explicit, syntactic dependency relation $p \rightarrow q$ is too coarse grained to answer natural questions like:

> *can I remove package p without affecting package q ?*

Answer may not be dependent on packages p and q only!
e.g.: alternative (OR-ed) dependencies, virtual packages

let's try again

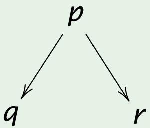
Strong dependencies

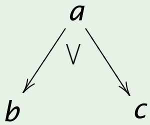
p strongly depends on q with respect to repository R ($p \Rightarrow_R q$) if it is not possible to install p without also installing q

Strong vs "normal" dependencies

Example

```
Package: p
Depends: q, r
Package: a
Depends: b | c
```



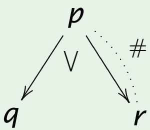


Strong deps: $p \Rightarrow q, p \Rightarrow r$

Example

...but in general things get more complicated:

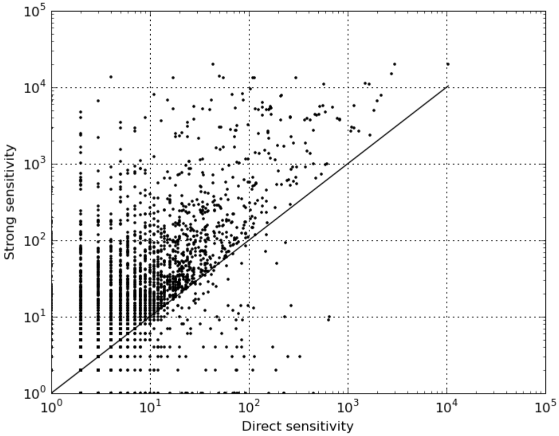
```
Package: p
Depends: q | r
Package: r
Conflicts: p
Package: q
```



the conflict can come from a galaxy far, far away ...

Strong deps: $p \Rightarrow q$

Correlation between strong and normal dependencies



(data from Lenny)

Impact Set and Package Sensitivity

Impact set: the set of packages potentially affected by changes in a given package.

Definition (Impact set of a component)

Given a repository R and a package p in R, the *impact set* of p in R is the set $Is(p, R) = \{q \in R \mid q \Rightarrow p\}$.
Similarly, the *direct impact set* of p is the set
$DirIs(p, R) = \{q \in R \mid q \rightarrow p\}$.

Definition (Sensitivity)

The strong sensitivity, or simply *sensitivity*, of a package $p \in R$ is $|Is(p, R)| - 1$, i.e., the cardinality of the impact set minus 1. Similarly, the *direct sensitivity* is the cardinality of the direct impact set.

Idea: sensitivity asses how "delicate" is a package.
How many packages can I break uploading/installing p ?

Top 15 of sensitive packages in Lenny

What's the most sensitive package in Lenny?

Top 15 of sensitive packages in Lenny

#	Package	$\|p\|$	$\|\|p\|\|$	$\|\|p\|\| - \|p\|$
1	gcc-4.3-base	43	20128	20085
2	libgcc1	3011	20126	17115
3	libselinux1	50	14121	14071
4	lzma	4	13534	13530
5	coreutils	17	13454	13437
6	dpkg	55	13450	13395
7	libattr1	110	13489	13379
8	libacl1	113	13467	13354
9	perl-base	299	13310	13011
10	libstdc++6	2786	14964	12178
11	libncurses5	572	11017	10445
12	debconf	1512	11387	9875
13	*libc6*	10442	20126	9684
14	libdb4.6	103	9640	9537
15	zlib1g	1640	10945	9305

...

Dominators

Intuition

p dominates q if the strong dependency of p on q “explains” the impact set of q, i.e., q is “important” due to a lot of other packages which requires p (it is the case for gcc-4.3-base)

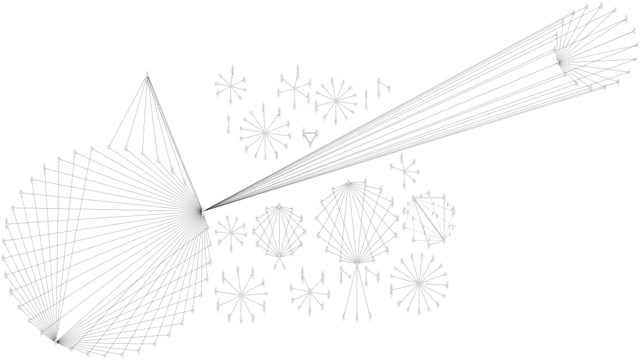
Definition

Strong dominance Given two packages p and q in a repository R, we say that p strongly dominates q ($p \succcurlyeq_{Is} q$) iff

- $Is(p, R) \supseteq (Is(q, R) \setminus Scons(p))$, and
- p strongly depends on q

The dominance relation gives a good device to highlight complex structure in the Debian dependency graph.

Strong dominance graphs in Debian



let's showcase some examples ...

Live data (all Debian releases + daily snapshots) available at
http://www.mancoosi.org/measures/

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Strong conflicts

- Like strong dependencies, but with conflicts!
- *a* and *b* conflict strongly iff they cannot be installed together

```
1591 ppmtofb-0.32 :
1591 (python-2.4.4-2 <-> ppmtofb-0.32)
* python-osd-0.2.12-1.2 (conjunctive)
- dependency: python-osd-0.2.12-1.2 -> python-2.4.4-2
- conflict: python-2.4.4-2 - ppmtofb-0.32
* python-oss-0.0.0.20010624-3.3 (conjunctive)
- dependency: python-oss-0.0.0.20010624-3.3 -> python-2.4.4-2
- conflict: python-2.4.4-2 - ppmtofb-0.32
...
```

`ppmtofb-0.32` ~~has~~ had 1591 strong conflicts, why?

- All caused by one explicit conflict
- In the metadata: conflict with python `> 2.4`

Better dependency solving

completeness each time a solution to an upgrade problem does exists, a meta-installer should be able to find it

optimality it should be possible to specify *optimization criteria* to discriminate among otherwise equivalent solutions, e.g.:

- minimize download size
- minimize used disk space
- minimize the number of sensitive package touched
- blacklist packages maintained by J. Random DD
- ...

efficiency dependency resolution should be as fast as possible

A dependency solver competition

We surely do not hope to find magically the silver bullet algorithm for dependency solving, but we can help the fate organizing a dependency solving competition

- real-life upgrade problem collected a-la popcon
- various *tracks*: plain resolution (speed), optimizing resolution (better solution), . . .
- developers and researchers can submit their implementations of their algorithms
- the winner gains fortune and glory

A distro-independent format to describe upgrade scenario has been developed: CUDF (Common Upgradeability Description Format)

- it can also be used to share dependency solver between package managers
- currently implemented in CUPT

Questions?

looking for something else than Q & A time?
. . . ok, here is ~~some SPAM~~ a friendly reminder: `http://www.mancoosi.org`