

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.

$$\text{libc6} \wedge (\text{libice6} \vee \text{xlibs}) \wedge \dots$$

... some care is required though:

- *multiple versions*: foo becomes foo_{1.0} | foo_{1.1} | ...
- *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)

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

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.:
 $a \text{ term} \rightarrow \text{libc6} \wedge (\text{libc6} \vee \text{xlibs}) \wedge \dots$
- 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.

¹deciding 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

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

... 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 uninstability
 - ▶ 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%

Stable:



Testing:



Unstable:



alpha

amd64

arm

hppa

i386

ia64

mips

mipsel

powerpc

pkg1ab

- pkg1ab 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: pkg1ab

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 unpredictable 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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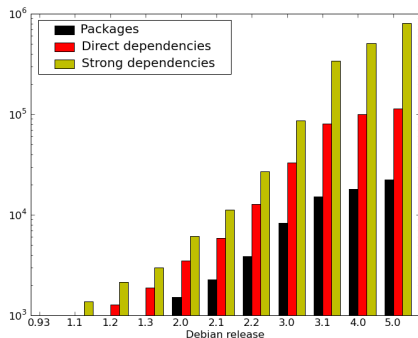
3 Future

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 of 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

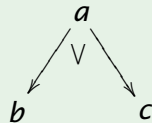
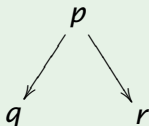
Strong dependencies

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

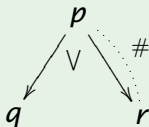


Strong deps: $p \Rightarrow q, p \Rightarrow r$

Example

... but in general things get more complicated:

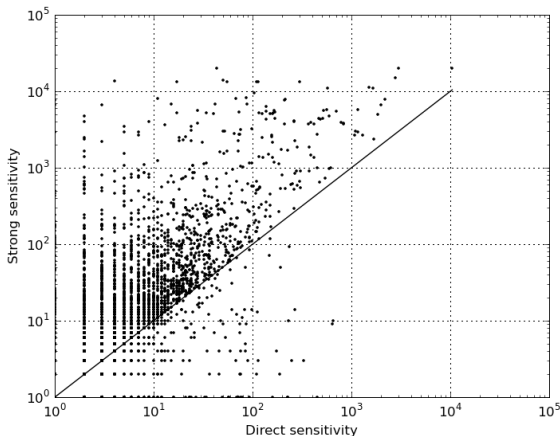
Package: p
Depends: q | r
Package: r
Conflicts: p
Package: q



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 assesses 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)

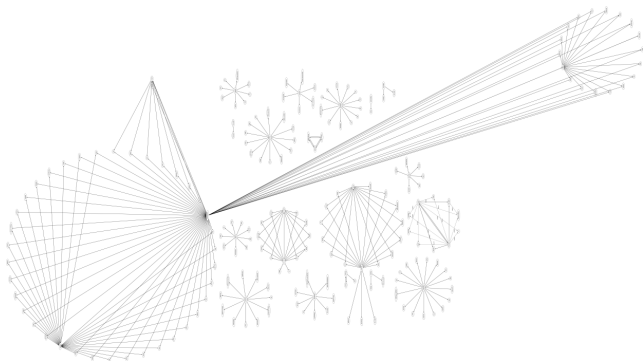
Definition

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