Software deployment with Nix

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Overview

TraCE Project

- Part of the NWO Jacquard program
- Universiteit Utrecht

Nix

What it does:

- Software deployment ("package management")
- Service deployment
- Continuous integration and release management
- Build management
- NixOS

Software Deployment

- Software deployment: the art of **transferring software** (components) from one machine to another (and managing it).
- "All activities that make a software system available for use" (Carzaniga et al. 1998)
- Covers activities such as:
  - Packaging
  - Transferring
  - Installing
  - Configuring
  - Updating
  - Uninstalling

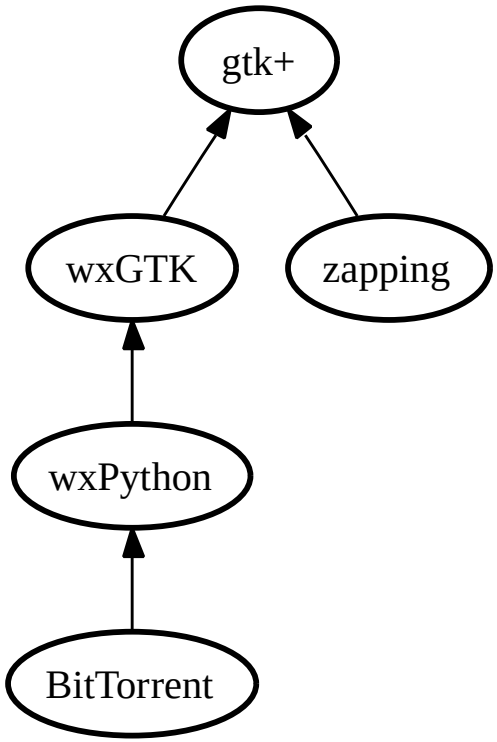
Deployment Problems

Software deployment (the act of transferring software to another system) is surprisingly hard.

- It's hard to ensure correctness (the software should work the same on the source and target systems).
- It's too much work.
- Deployment systems tend to be inflexible.

So why is this hard?

- Difficult to have multiple versions; but we want this to
  - Test upgrades
  - Deal with conflicting dependencies
  - Support different user / service requirements



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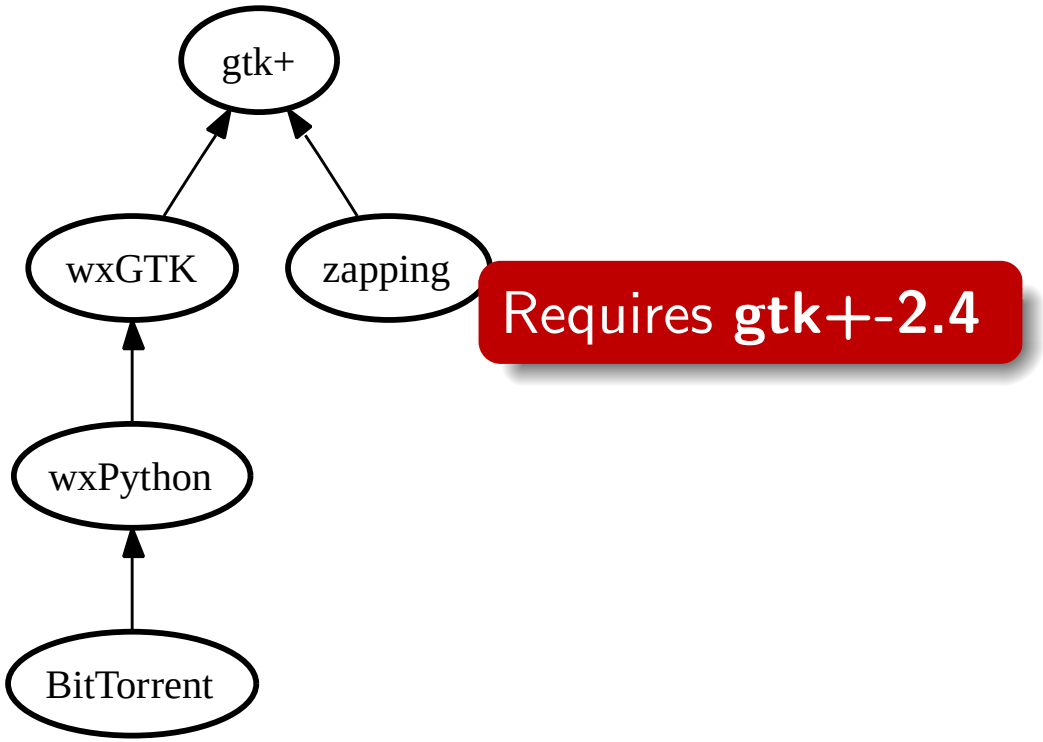

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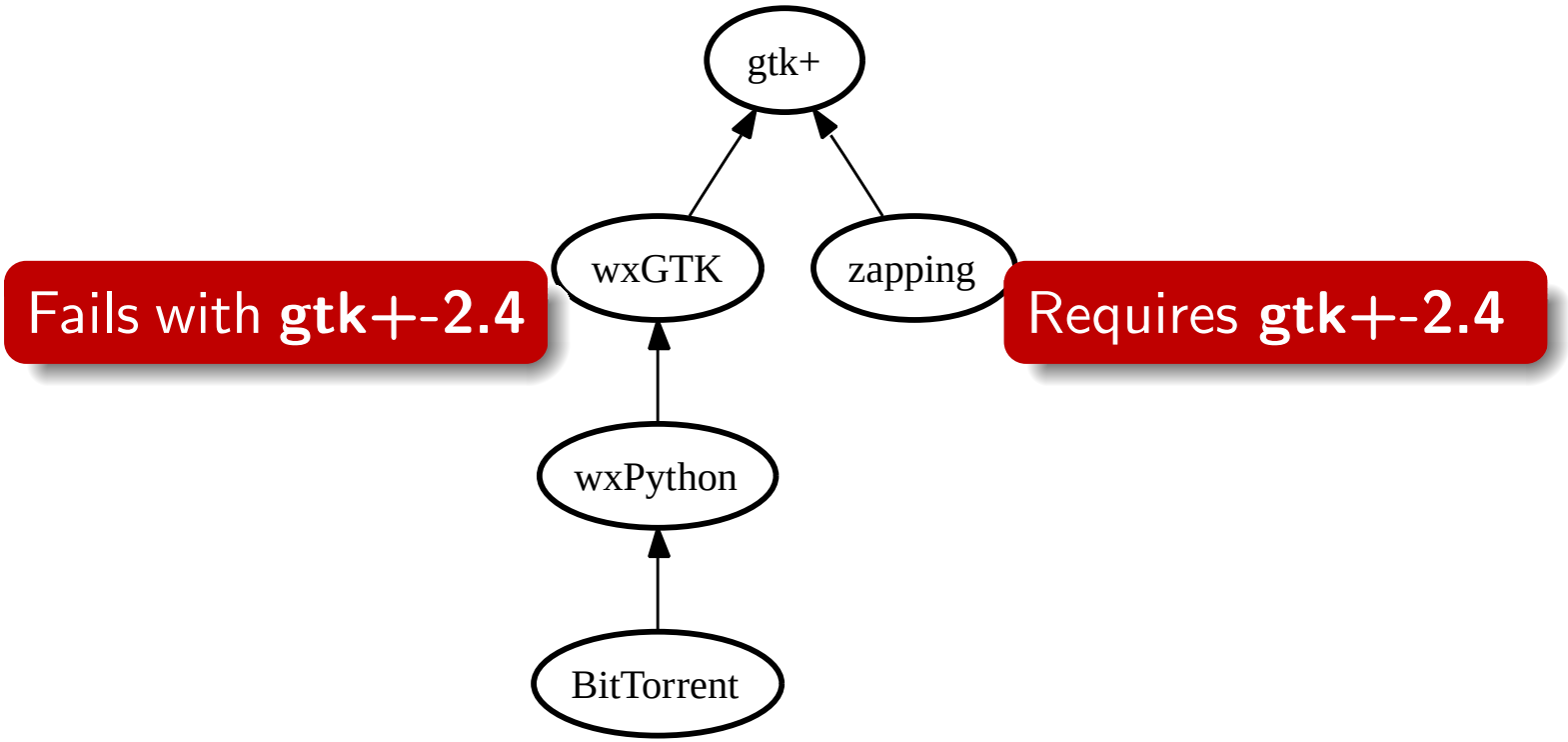

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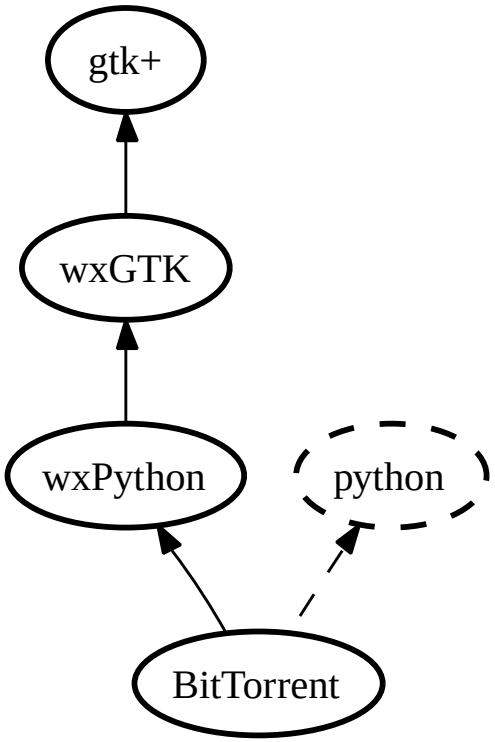
  - What components are needed?
  - What versions?



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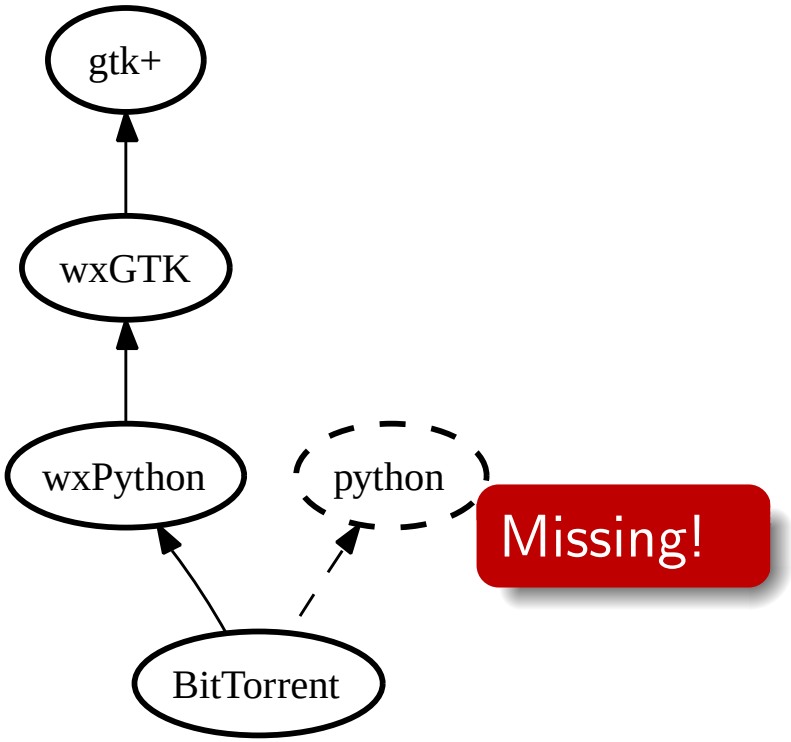

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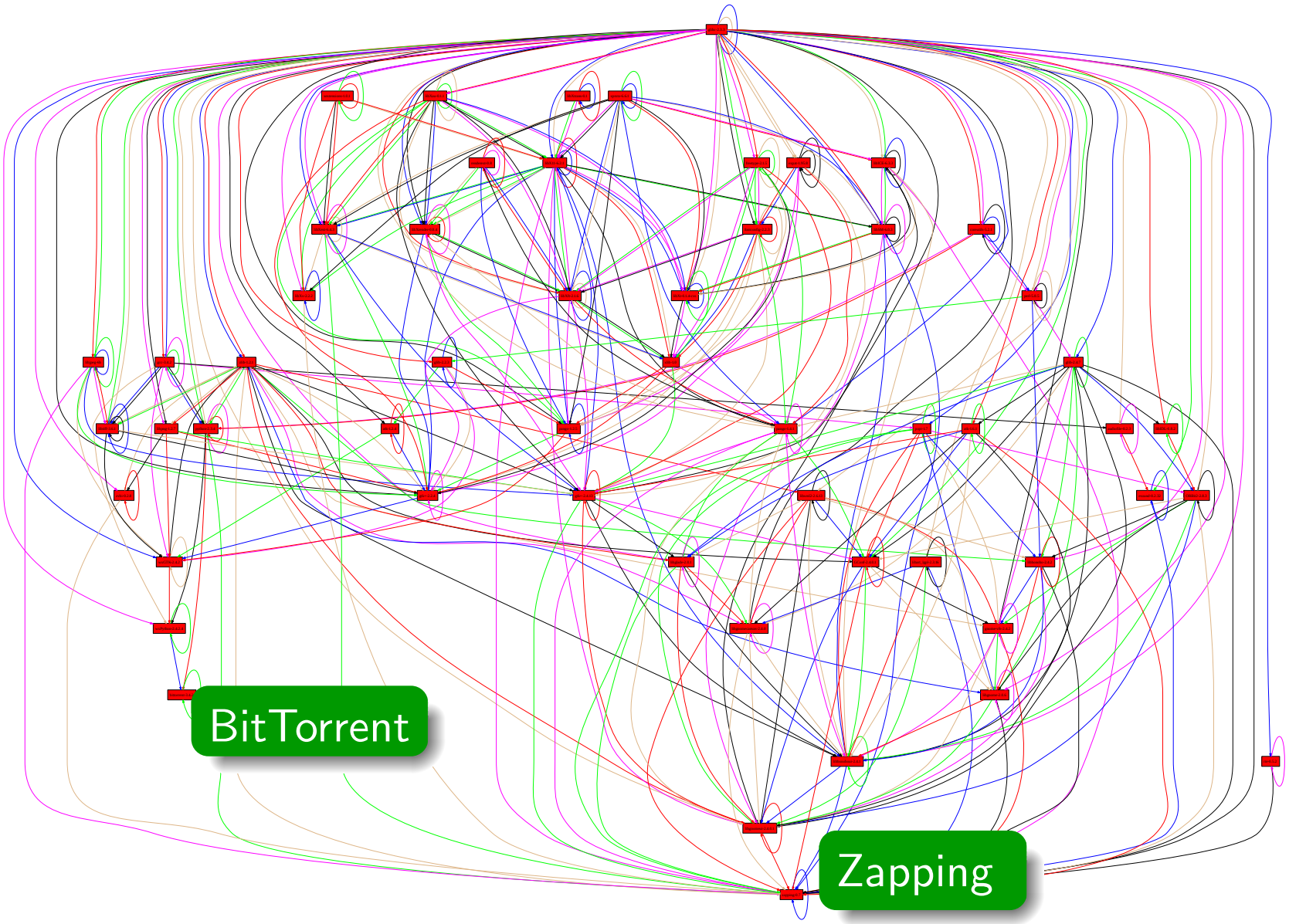

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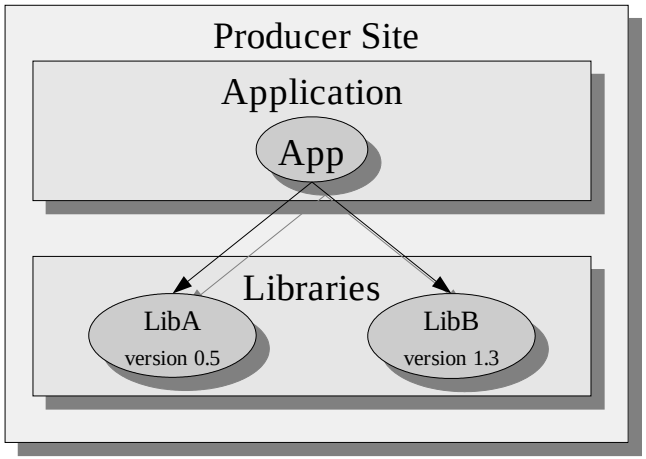

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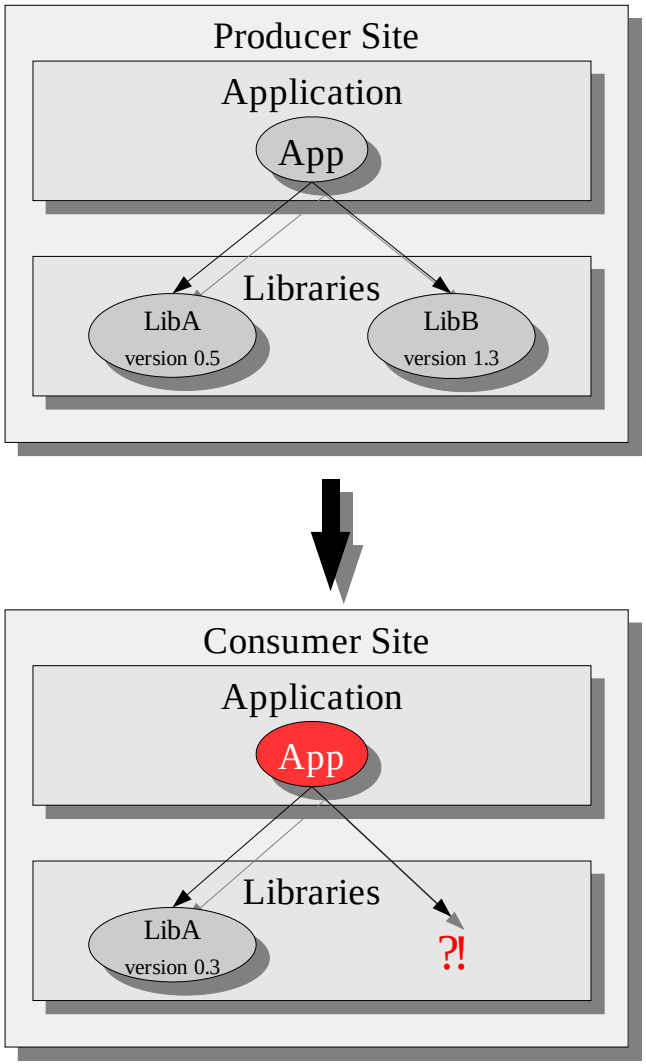

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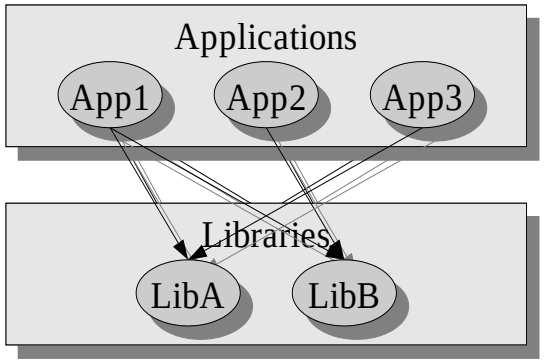
Component Interference



Operations on a component (install, upgrade, remove) often break other components (*interference*). E.g.:

- Upgrade of App2 breaks App1 due to upgrade of LibB to LibB'
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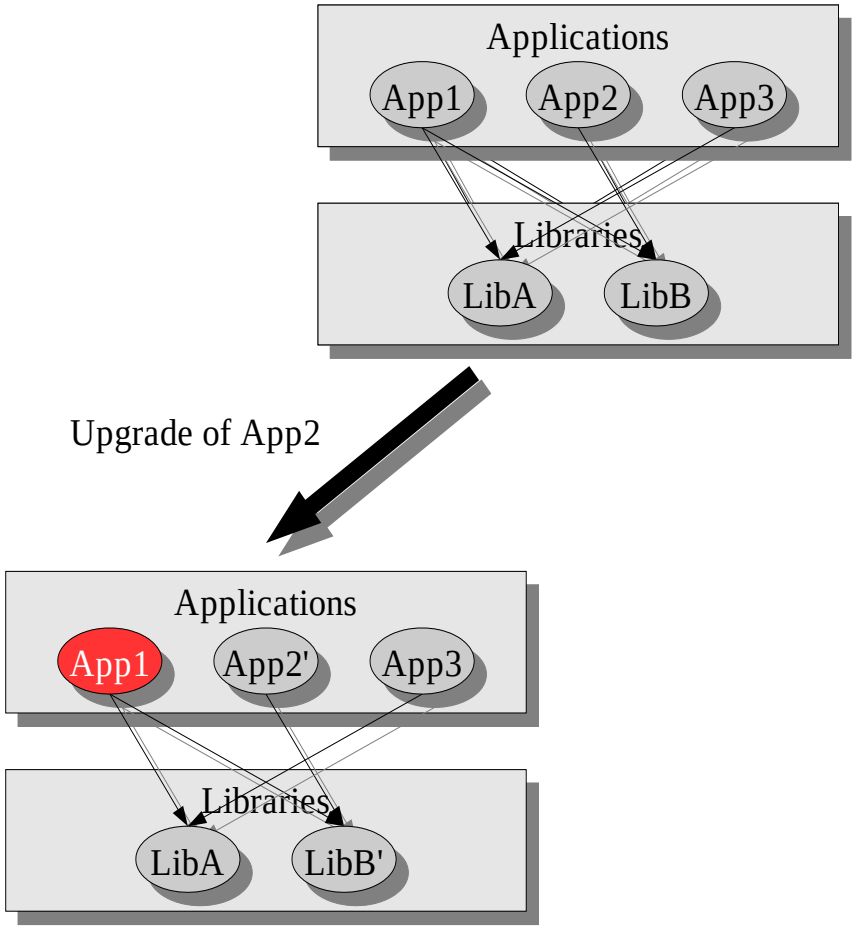

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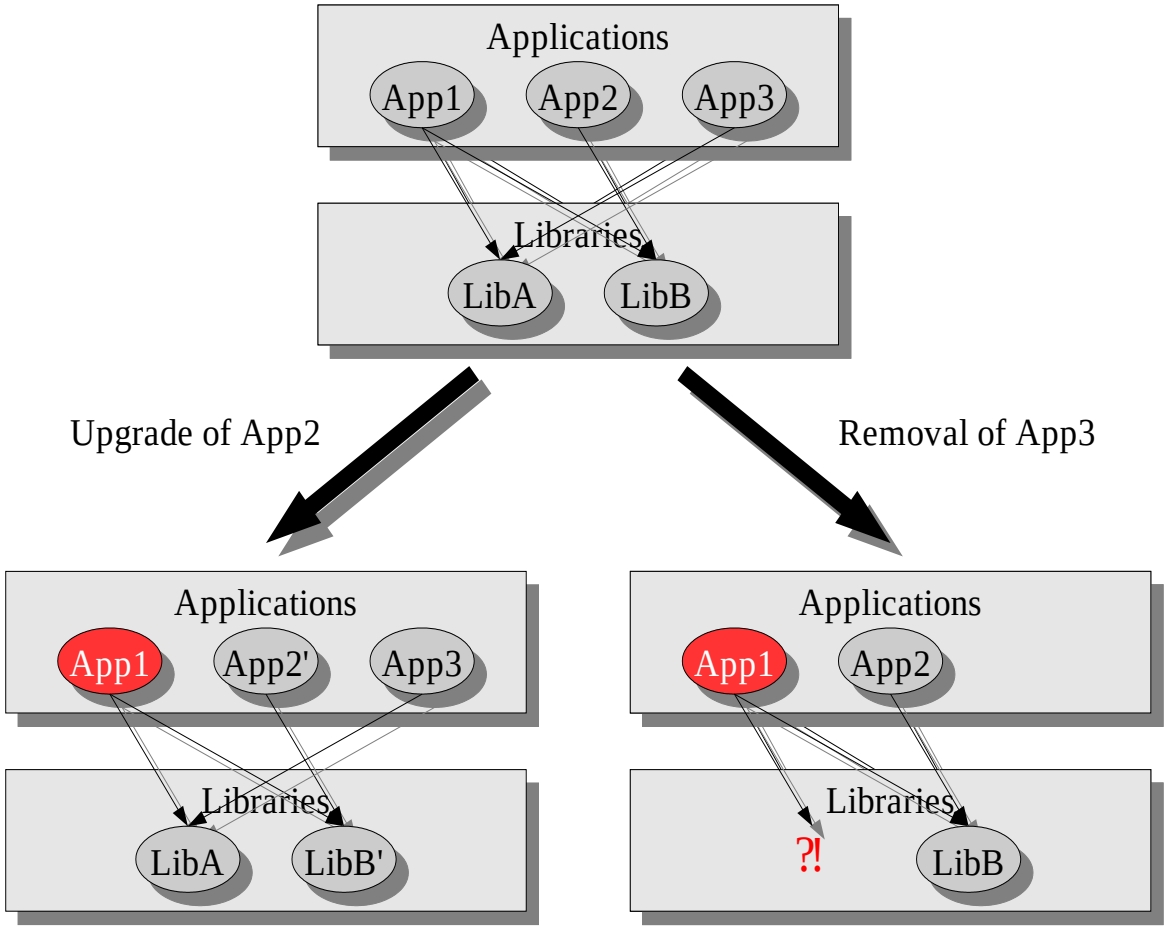

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Tool Support

- Deployment was (is) often done in an *ad hoc*, undisciplined fashion.
  - Files installed in global locations (**/usr/bin**, **C:/Windows/System32**).
  - "DLL Hell" — overwriting of shared components with older/newer versions.
  - "Dependency Hell" — components may have gazillions of dependencies.
  - Each application has its own (un)installer (so no unified view on the system).
  - Interactive installers ⇒ considered harmful (hard to automate).
  - Packaging = lots of work.
- Package managers manage software installations in a unified way: RPM, FreeBSD Ports/Packages, Depot, Debian apt-get/dpkg, ..., Nix.

Requirements on a Deployment System

- Support multiple versions, variants.
- Handle dependencies.
- Ensure safe upgrades / uninstalls.
- Atomic upgrades/downgrades (e.g., important in server environments).
- Provide a good composition mechanism.
- Allow different "views" for multiple users.
- Unique identification of configurations.
- ...

The Nix Deployment System

- Central idea: store all components in isolation.
- Unique paths:

```
/nix/store/jjp9pirx8b3nqs9k...-firefox
```

  which is an SHA-256 hash of **all** inputs used to build the component:
  - Sources
  - Libraries
  - Compilers
  - Build scripts
  - Build parameters
  - System type
  - ...
- **Prevent** undeclared **build time** dependencies.
- **Scan** for **runtime** dependencies.
- Deploy only **closures** under the **depends-on** relation.

Nix store

```
/nix/store
├── bd6593219f8dcb63...-gtk+-2.2.4
│   └── lib
│       └── libgtk-x11-2.0.so.0
├── ce2d7d2a41456bab...-wxGTK-2.4.2
│   └── lib
│       └── libwx_gtk2-2.4.so
├── e889db0595672287...-wxPython-2.4.2.4
│   └── (lots of Python bindings)
├── 9ed8c4231bfde4af...-bittorrent-3.4.2
│   └── bin
│       └── btdownloadgui.py
├── 300ccc1a41af3abc...-gtk+-2.4.13
│   └── lib
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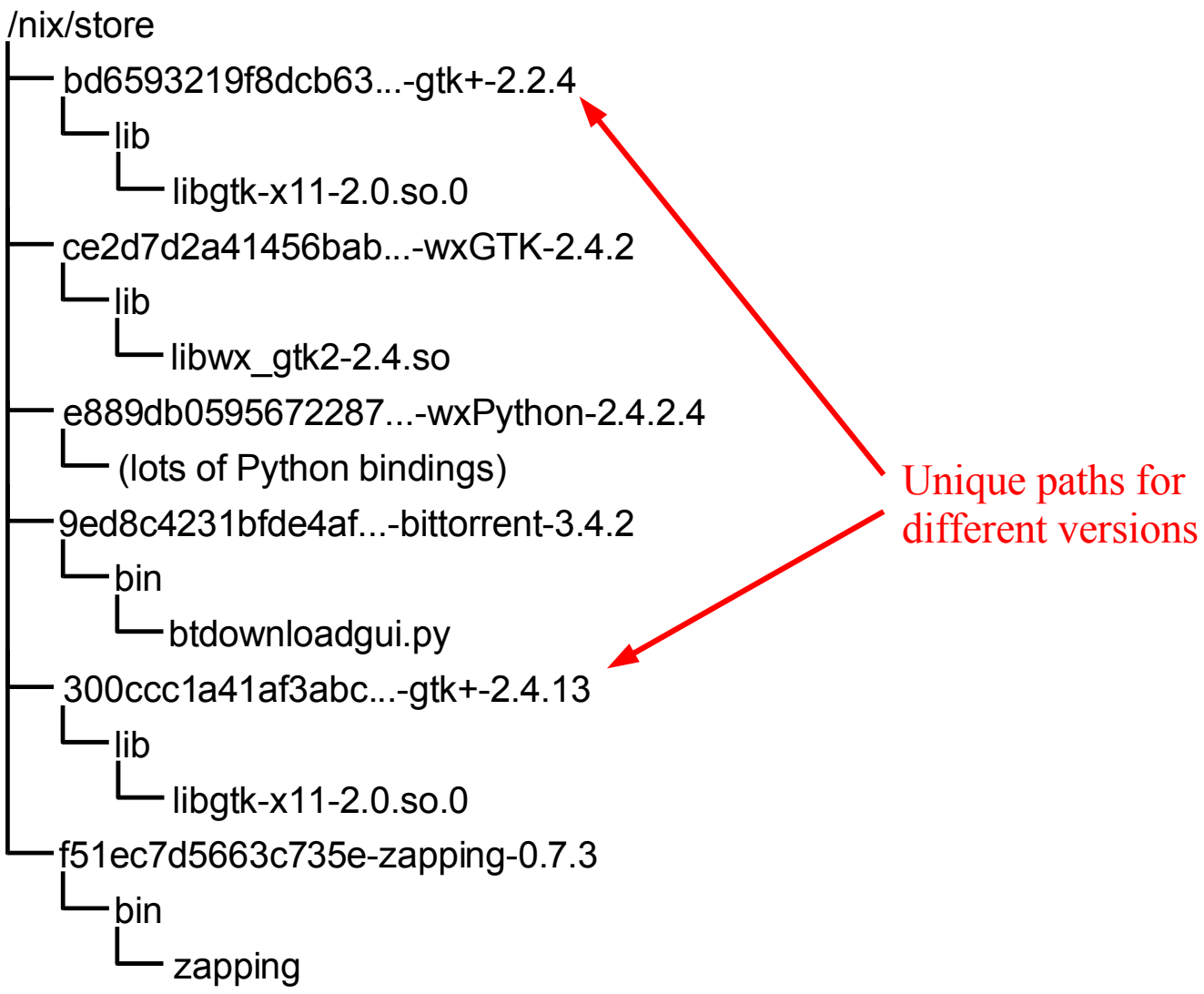
Nix store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Unique paths for different versions

Nix expressions

hello/default.nix

```
{stdenv, fetchurl, perl}:

stdenv.mkDerivation {
  name = "hello-2.1.1";
  builder = ./builder.sh;
  src = fetchurl {
    url =
      ftp://ftp.gnu.org/pub/gnu/hello/hello-2.1.1.tar.gz;
    md5 = "70c9ccf9fac07f762c24f2df2290784d";
  };
  inherit perl;
}
```

Nix expressions

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Function arguments

Nix expressions

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  };
  inherit perl;
}
```

Function arguments

Build attributes

Nix expressions

hello/builder.sh

```
source $stdenv/setup

PATH=$perl/bin:$PATH

tar xvfz $src
cd hello-*
./configure --prefix=$out
make
make install
```

Nix expressions

hello/builder.sh

```
source $stdenv/setup

PATH=$perl/bin:$PATH

tar xvfz $src
cd hello-*
./configure --pref
make
make install
```

Environment initially empty; prevents undeclared dependencies

Nix expressions

system/all-packages-generic.nix

```
hello = (import ../applications/misc/hello/ex-1) {
  inherit fetchurl stdenv perl;
};

perl = (import ../development/interpreters/perl) {
  inherit fetchurl stdenv;
};

fetchurl = (import ../build-support/fetchurl) {
  inherit stdenv; ...
};

stdenv = ...;
```

Nix expressions

system/all-packages-generic.nix

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fetchurl = (import ../build-support/fetchurl) {
  inherit stdenv; ...
};

stdenv = ...;
```

Variability

```
bittorrent = (import ../tools/networking/bittorrent) {
  inherit fetchurl stdenv wxGTK;
};

wxGTK = (import ../development/libraries/wxGTK) {
  inherit fetchurl stdenv pkgconfig;
  gtk = gtkLibs22.gtk;
};

firefox = (import ../applications/browsers/firefox) {
  inherit fetchurl stdenv pkgconfig perl zip libIDL libXi;
  gtk = gtkLibs24.gtk;
};
```

Variability

```
{ localServer, stdenv, fetchurl
, openssl ? null, db4 ? null, ... }:

assert localServer -> db4 != null;
assert sslSupport
  -> openssl != null &&
  && (httpServer -> httpd.openssl == openssl);

stdenv.mkDerivation {
  name = "subversion-1.1.3";
  builder = ./builder.sh;
  src = fetchurl {url=...};
  ...
}
```

Finding runtime dependencies

```
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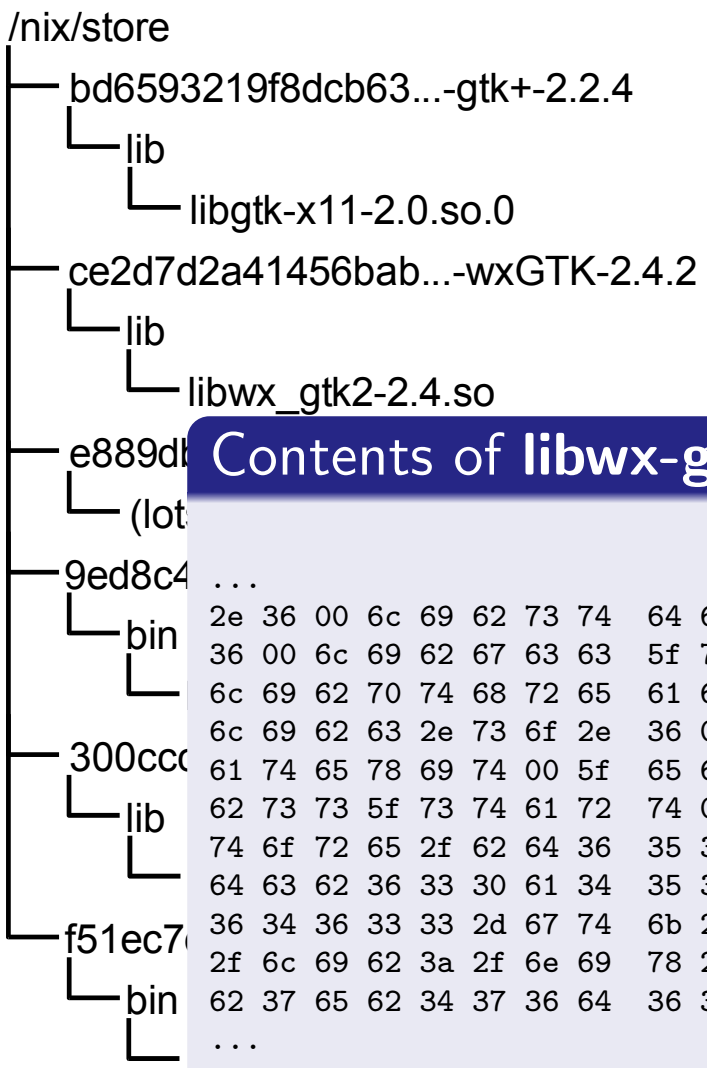

Contents of **libwx-gtk2-2.4.so**

```
...
2e 36 00 6c 69 62 73 74  64 63 2b 2b 2e 73 6f 2e  |.6.libstdc++.so.|
36 00 6c 69 62 67 63 63  5f 73 2e 73 6f 2e 31 00  |6.libgcc_s.so.1.|
6c 69 62 70 74 68 72 65  61 64 2e 73 6f 2e 30 00  |libpthread.so.0.|
6c 69 62 63 2e 73 6f 2e  36 00 5f 5f 63 78 61 5f  |libc.so.6.__cxa_|
61 74 65 78 69 74 00 5f  65 64 61 74 61 00 5f 5f  |atexit._edata.__|
62 73 73 5f 73 74 61 72  74 00 2f 6e 69 78 2f 73  |bss_start./nix/s|
74 6f 72 65 2f 62 64 36  35 39 33 32 31 39 66 38  |tore/bd6593219f8|
64 63 62 36 33 30 61 34  35 35 62 31 61 35 37 66  |dcb630a455b1a57f|
36 34 36 33 33 2d 67 74  6b 2b 2d 32 2e 32 2e 34  |64633-gtk+-2.2.4|
2f 6c 69 62 3a 2f 6e 69  78 2f 73 74 6f 72 65 2f  |/lib:/nix/store/|
62 37 65 62 34 37 36 64  36 32 62 61 65 38 62 63  |b7eb476d62bae8bc|
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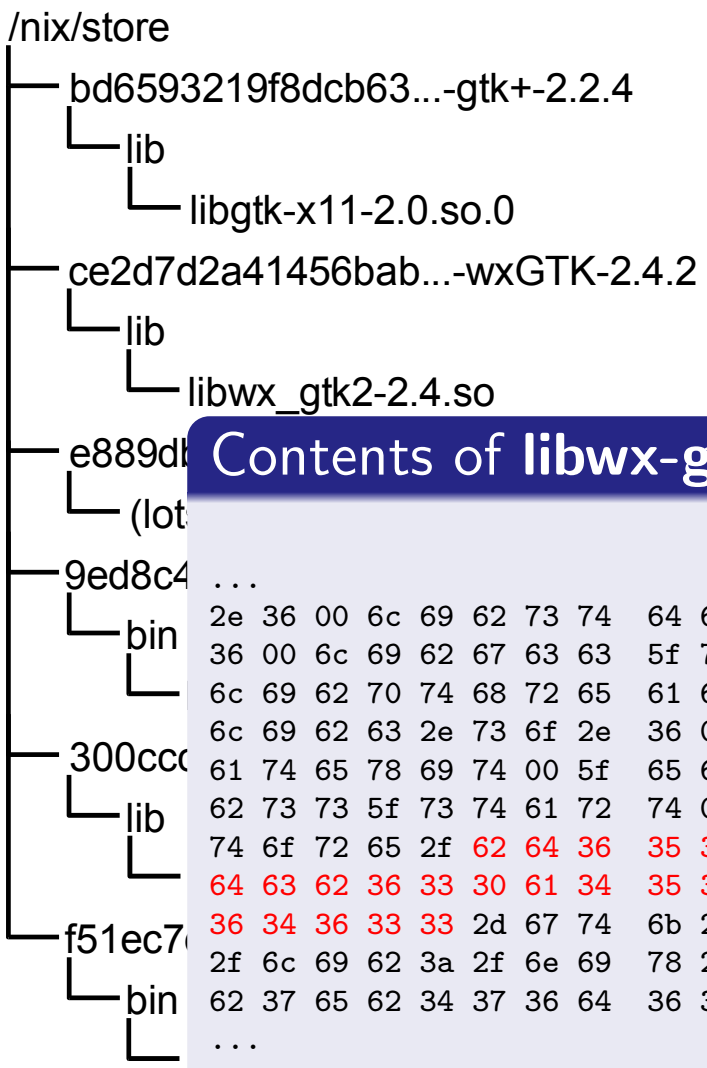

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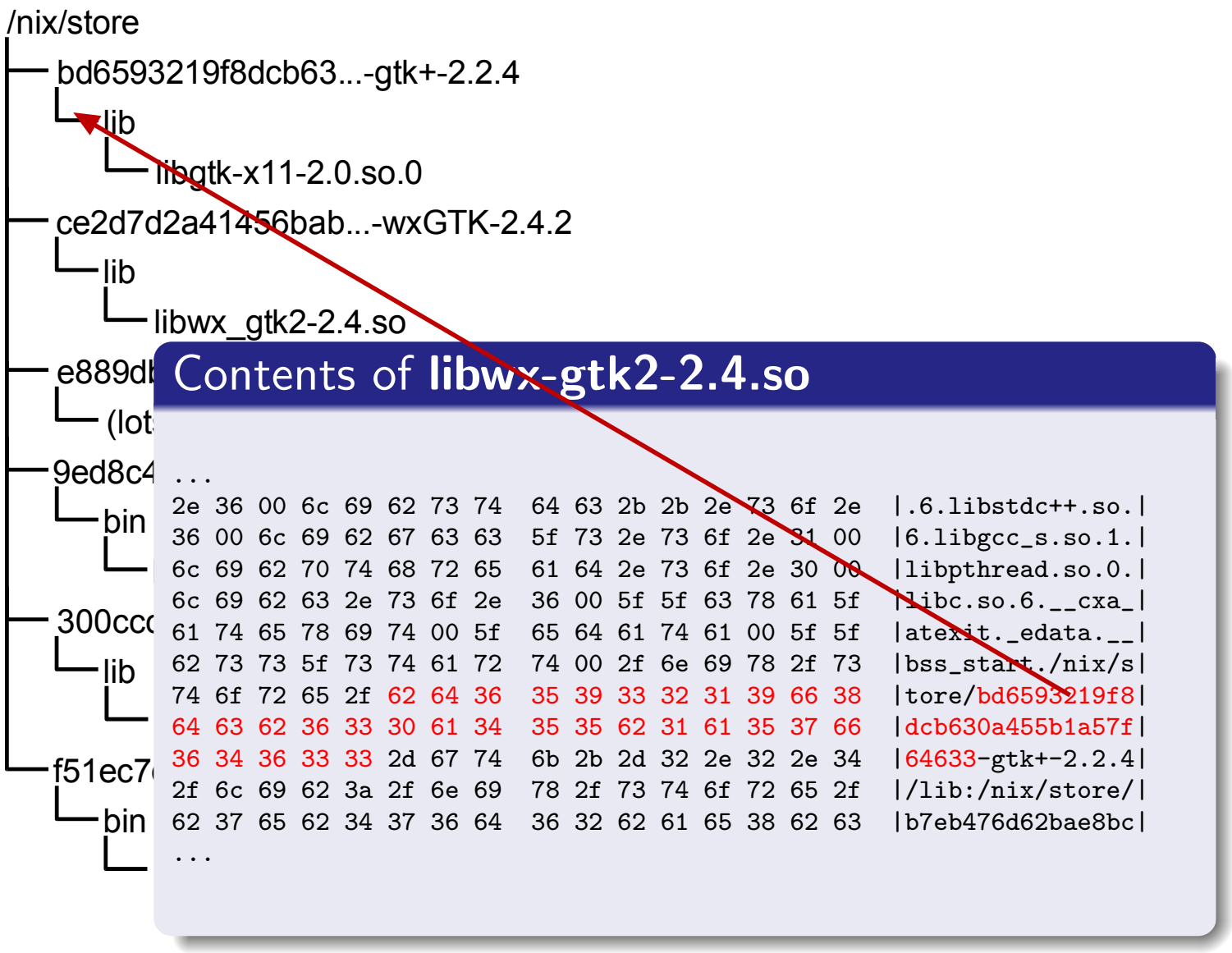

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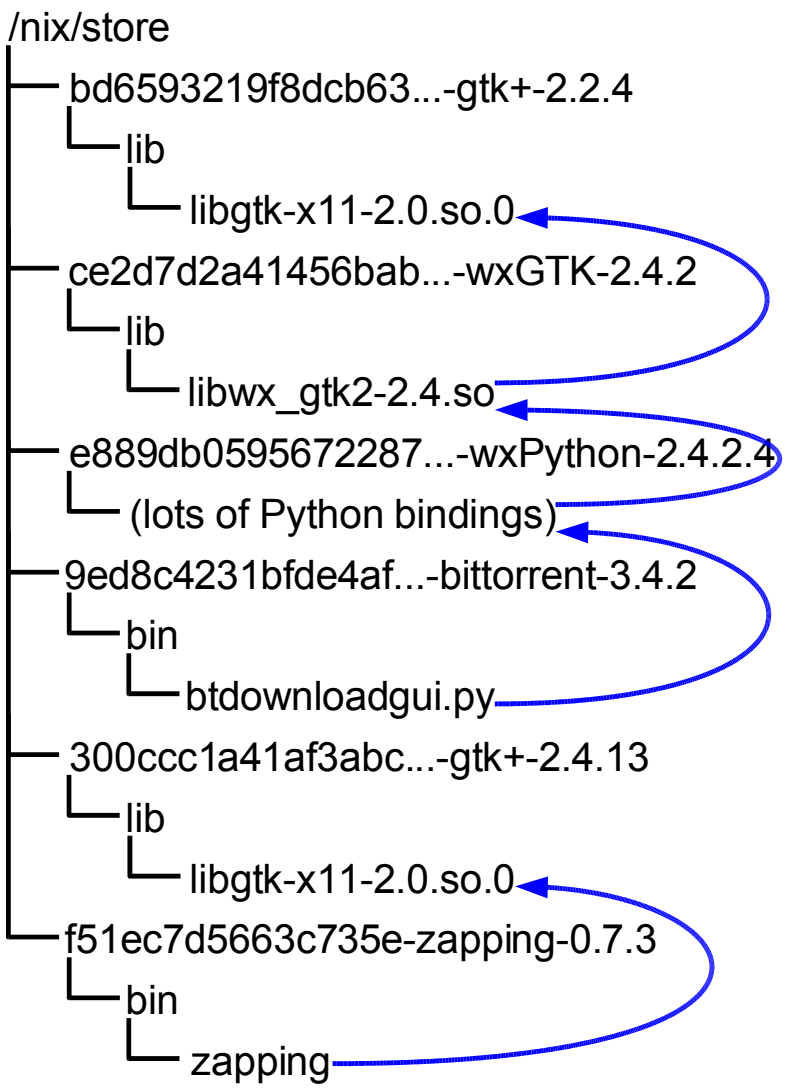

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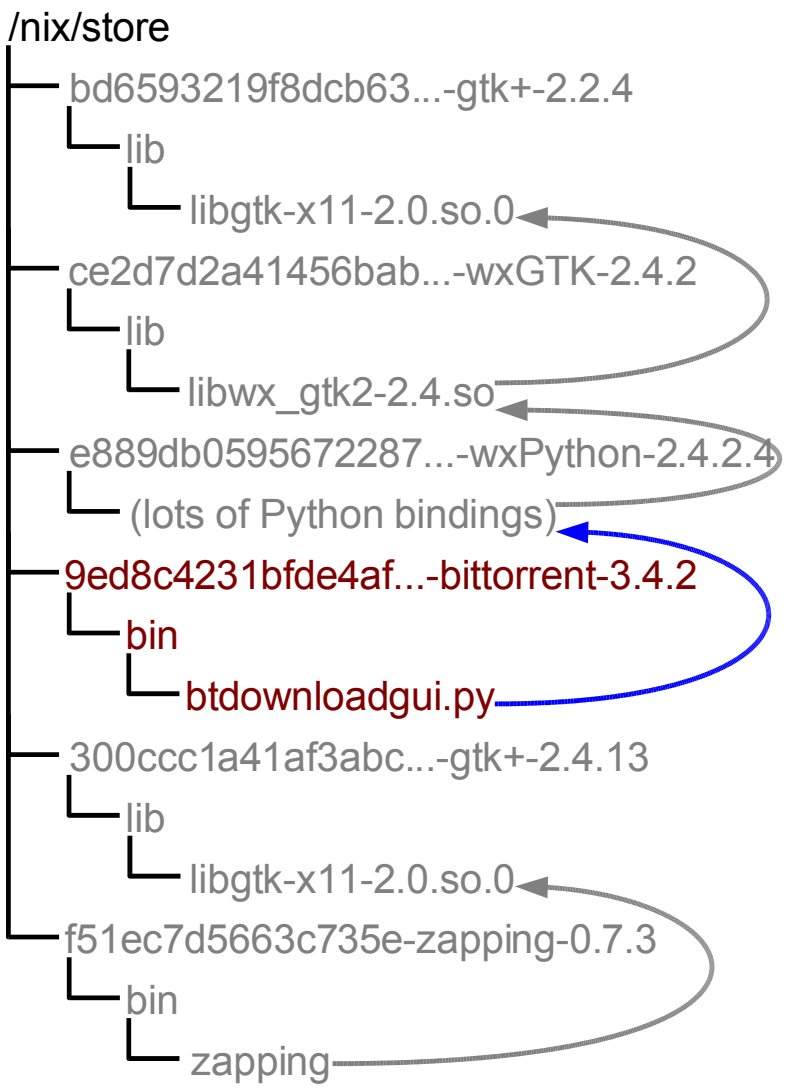

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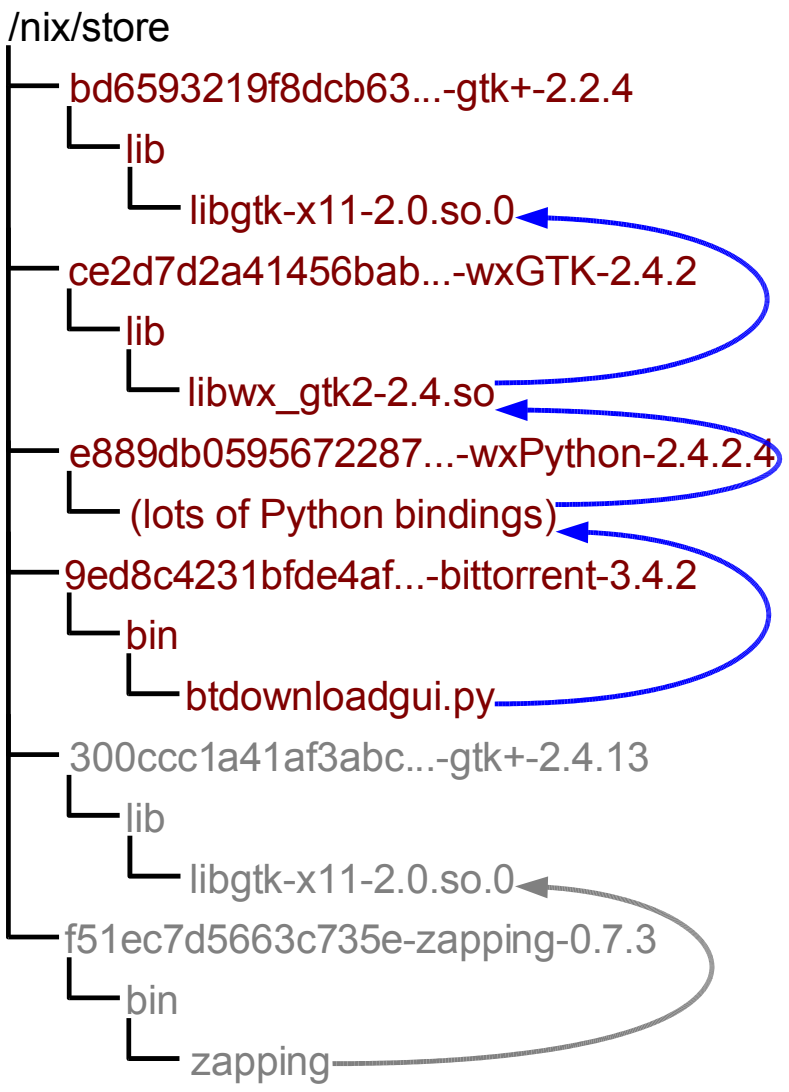

User operations

- To build and install Hello:

```
$ nix-env -if .../all-packages.nix hello
```

- When a new version comes along:

```
$ nix-env -uf .../all-packages.nix hello
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- If it doesn't work:

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- Delete unused components:

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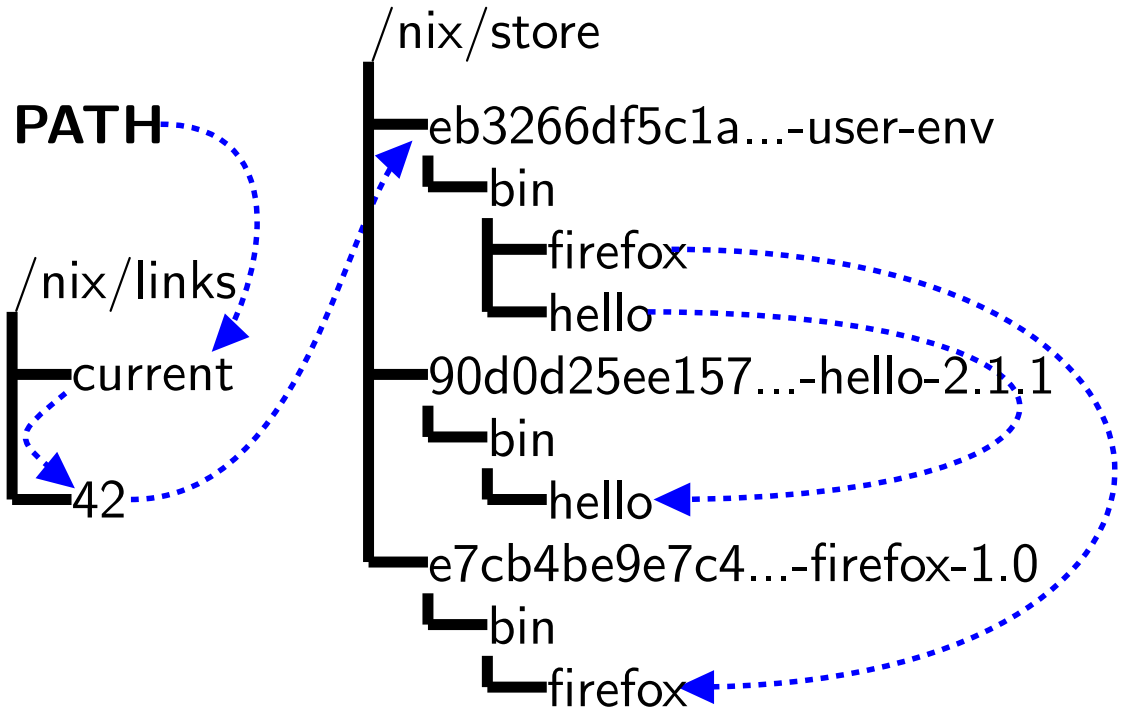
- Users can have different sets of installed applications.
- **nix-env** operations create new **user environments** in the store.
- We can atomically switch between them.
- These are roots of the **garbage collector**.



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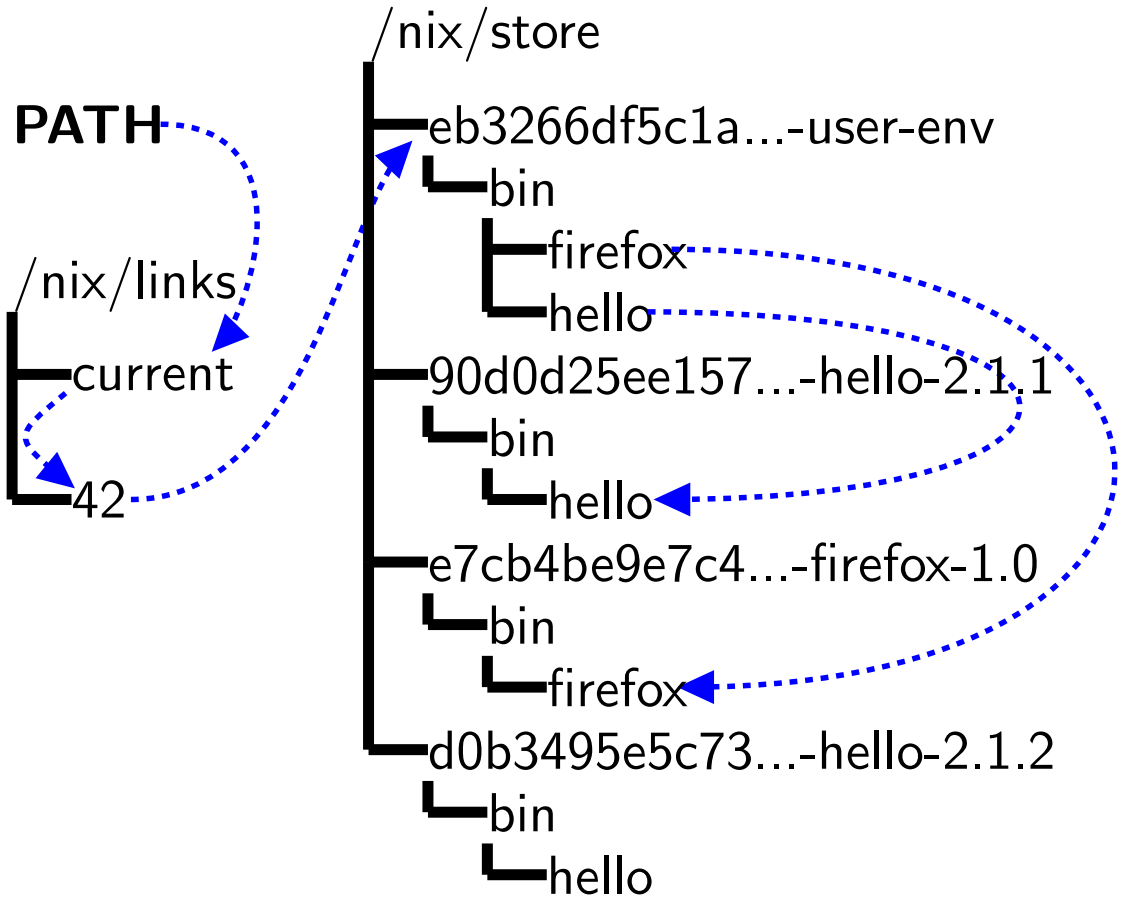

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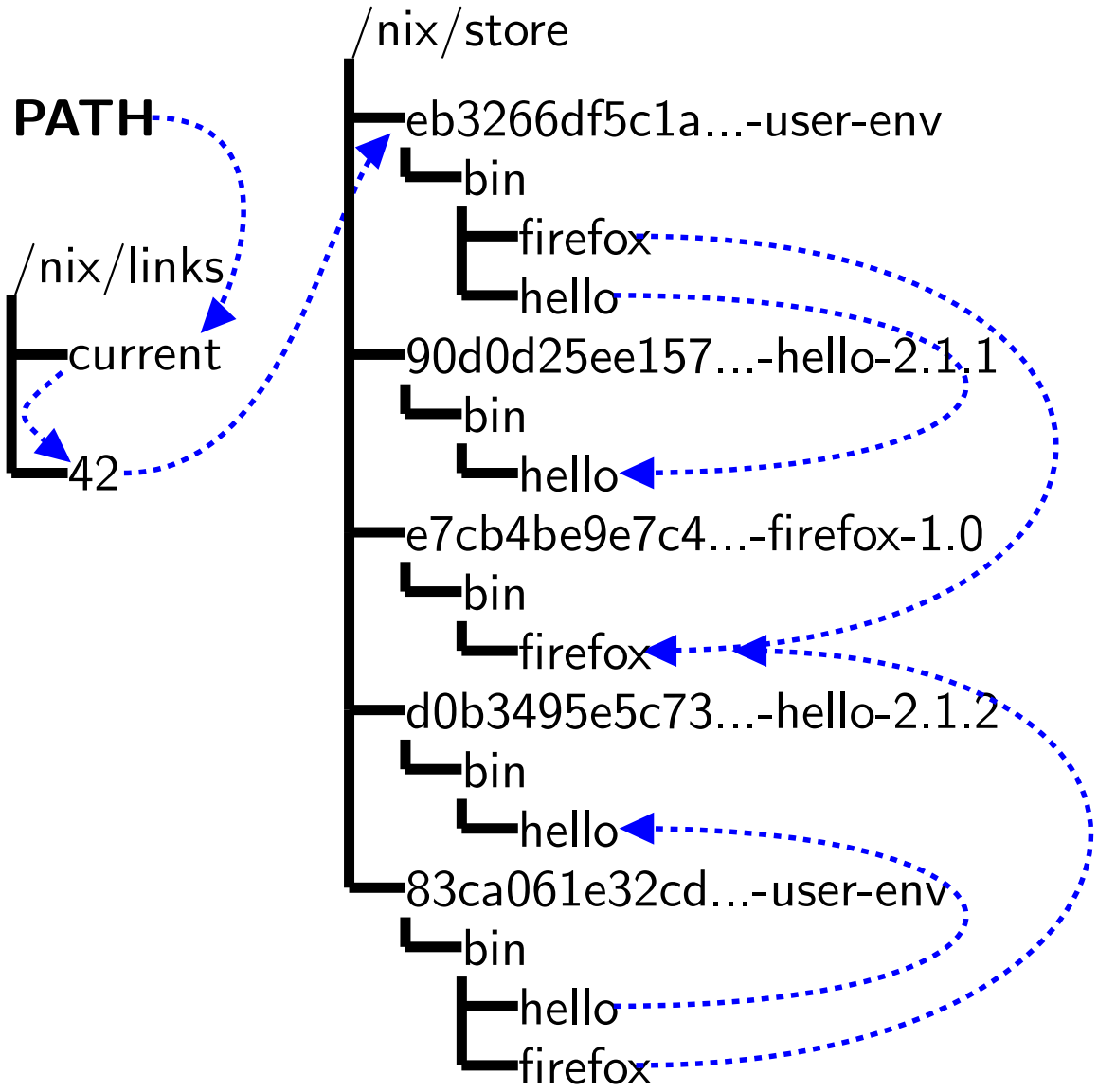

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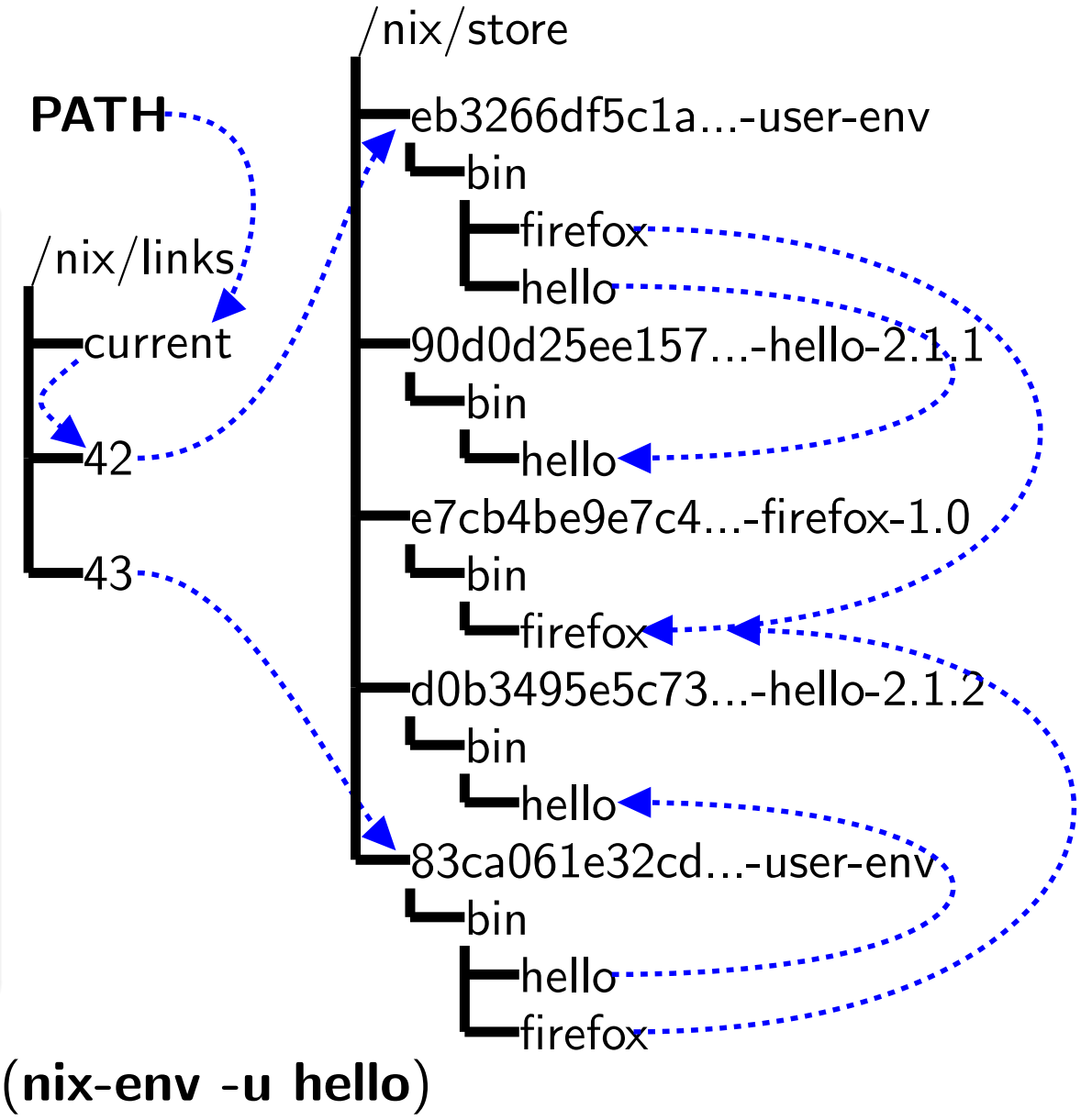

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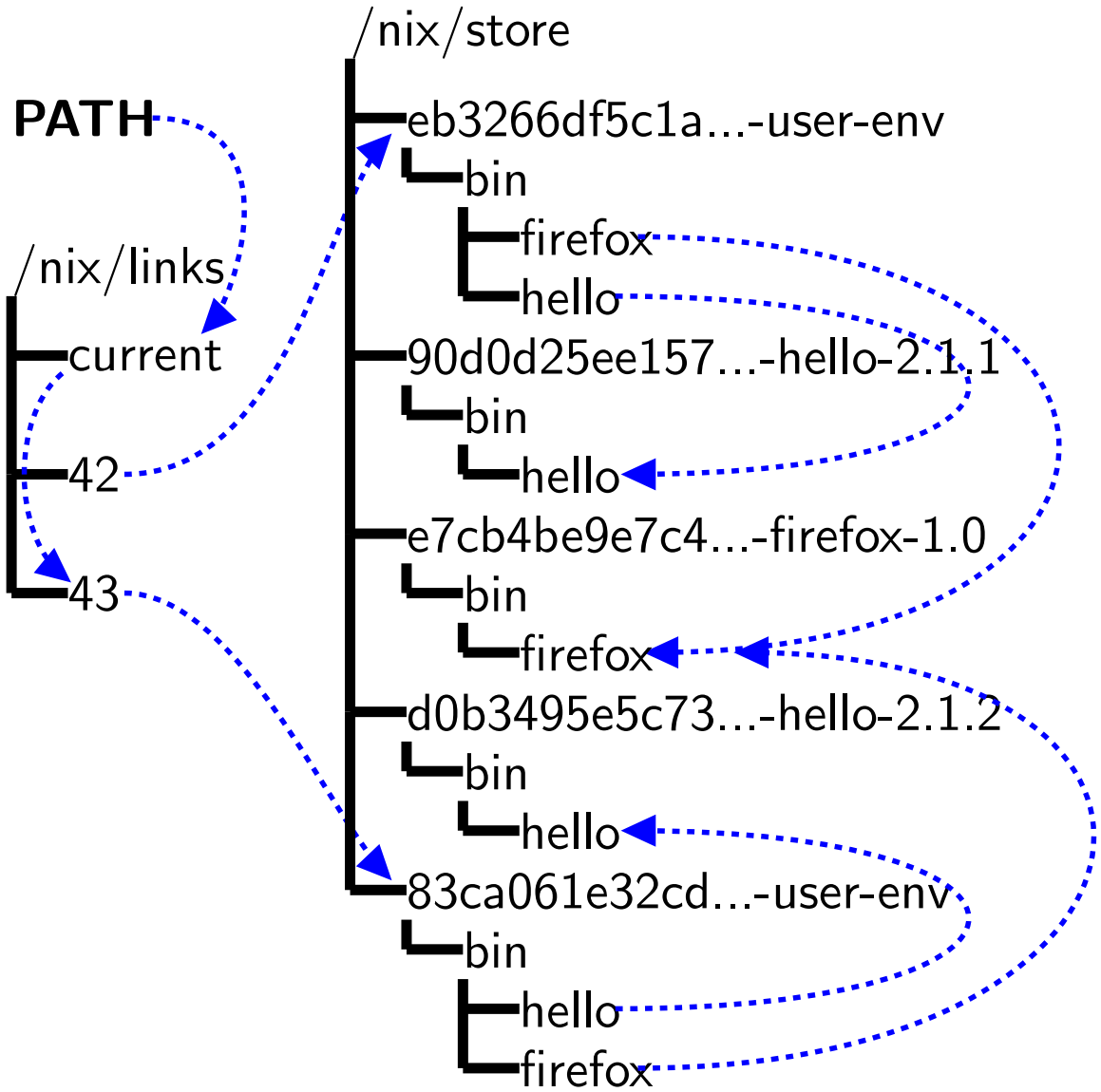

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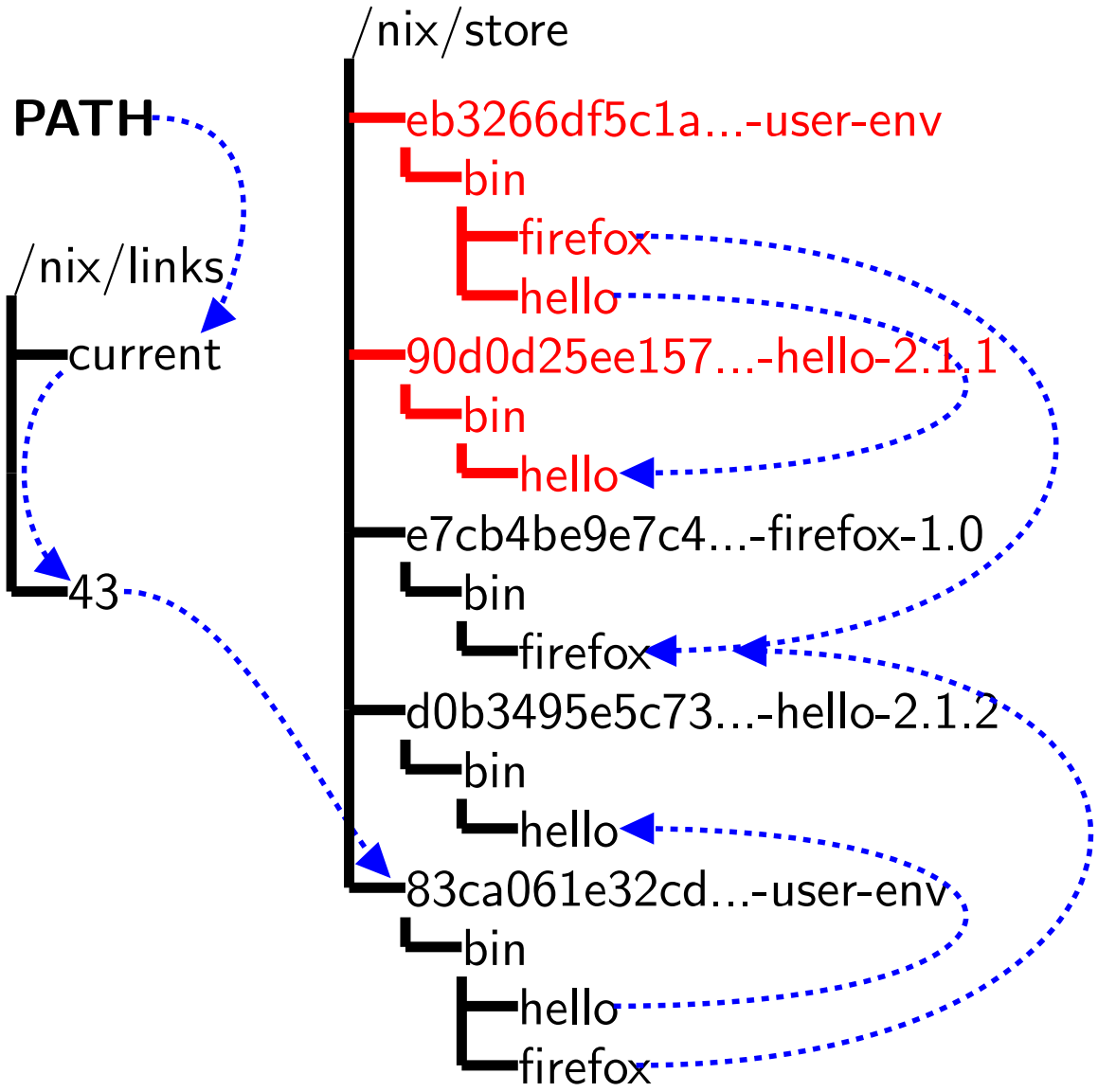

(**nix-env –remove-generations old**)

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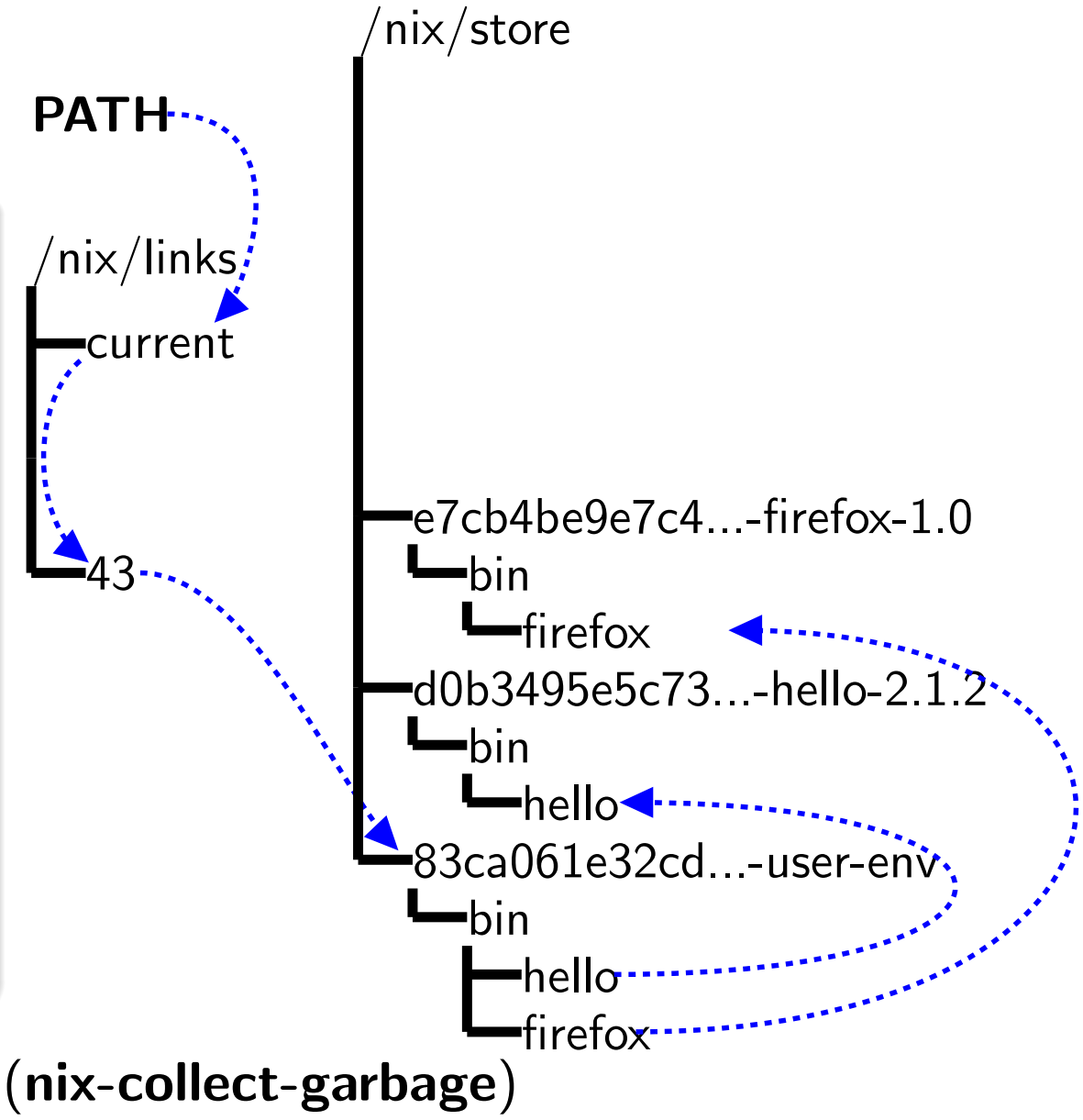

Deployment using Nix

- This is conceptually a **source deployment model**.
- We get **binary deployment** by sharing pre-built components.
- On the producer side:

```
$ nix-push $(nix-instantiate .../all-packages.nix) \
  http://server/cache
```

- On the client side:

```
$ nix-pull http://server/cache
$ nix-env -if .../all-packages.nix hello
```

- Installation will now reuse pre-built components, **iff** they are exactly the same.

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An example deployment policy: channels

- Channels allow Nix expressions to be updated automatically.
- Subscribe to a channel:

```
$ nix-channel --add http://.../channels/nixpkgs-stable
```

- Fetch latest channel instance:

```
$ nix-channel --update
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- Update all installed packages:

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Service deployment

Services: sets of running programs that provide some useful facility on a system or network.

Example: Subversion service

Subversion Repoman - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

https://svn.cs.uu.nl:12443/repoman

Go

Universiteit Utrecht

Subversion Server

Administrative tasks

- You can create a new repository.
- You can add a new user (only within the `cs.uu.nl` domain).
- You can edit your user information.

Online information

- Subversion homepage.
- Subversion: The Definitive Guide.

Repositories

The following repositories are hosted on this server:

Name	Owner	Description
3bate	kuipers	Repository van 3bate
adaptivewavelets	dijkema	Adaptive Wavelet Project
aefs	eelco	Portable cryptographic file system
afp-excercises-jenr	neus	afp
afp-exercises	bdumitri	Advanced Functional Programming exercises (Bogdan, Ze)
afp-exercises-ra	rjlwanro	AFP 2005 Exercises, Rjlwanro, Amiddelk
afp-project	bdumitriu	Advanced Functional Programming project (Ze, Bogdan, Huanwen, Jinfeng)

Done

svn.cs.uu.nl:12443

Example: Issue tracking service

[#NIXOS-16] NixOS should not wipe my hard drive - Stratego/XT JIRA - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

https://bugs.cs.uu.nl/browse/NIXOS-16

JIRA Stratego/XT JIRA

History | Log In

HOME BROWSE PROJECT FIND ISSUES CREATE NEW ISSUE QUICK SEARCH:

Issue Details [XML]

Key: NIXOS-16
Type: Bug
Status: Open
Priority: Blocker
Assignee: Armijn Hemel
Reporter: Eelco Dolstra
Votes: 0
Watchers: 0

Operations

- Clone this issue
- Comment on this issue

If you were logged in you would be able to see more operations.

NixOS

NixOS should not wipe my hard drive

Created: 2005-08-23 14:26 Updated: 2005-08-23 14:26

Return to search

Issue **14** of **25** issue(s)

<< Previous | NIXOS-16 | Next >>

Component/s: None
Affects Version/s: None
Fix Version/s: None

Original Estimate:	Unknown	Remaining Estimate:	Unknown	Time Spent:	Unknown

Description

The installer should

a) ask for confirmation before installing
b) not wipe the existing Nix store but reuse it

All Comments Work Log Change History Sort Order:

There are no comments yet on this issue.

This site is running on Atlassian JIRA with a free **Open Source Project / Non-profit License** (license details).
JIRA is an issue and bug tracking application. Evaluate JIRA for your organisation.

Done bugs.cs.uu.nl

Service deployment is hard

Service deployment involves a number of steps:

- Deploy software components (e.g., Apache, PostgreSQL, Subversion)
- Edit configuration files (e.g., **httpd.conf**, **viewcvs.conf**)
- Initialise state (e.g., logging directories, database tables)
- Start/stop processes
- ... and all of this possibly on multiple machines / platforms

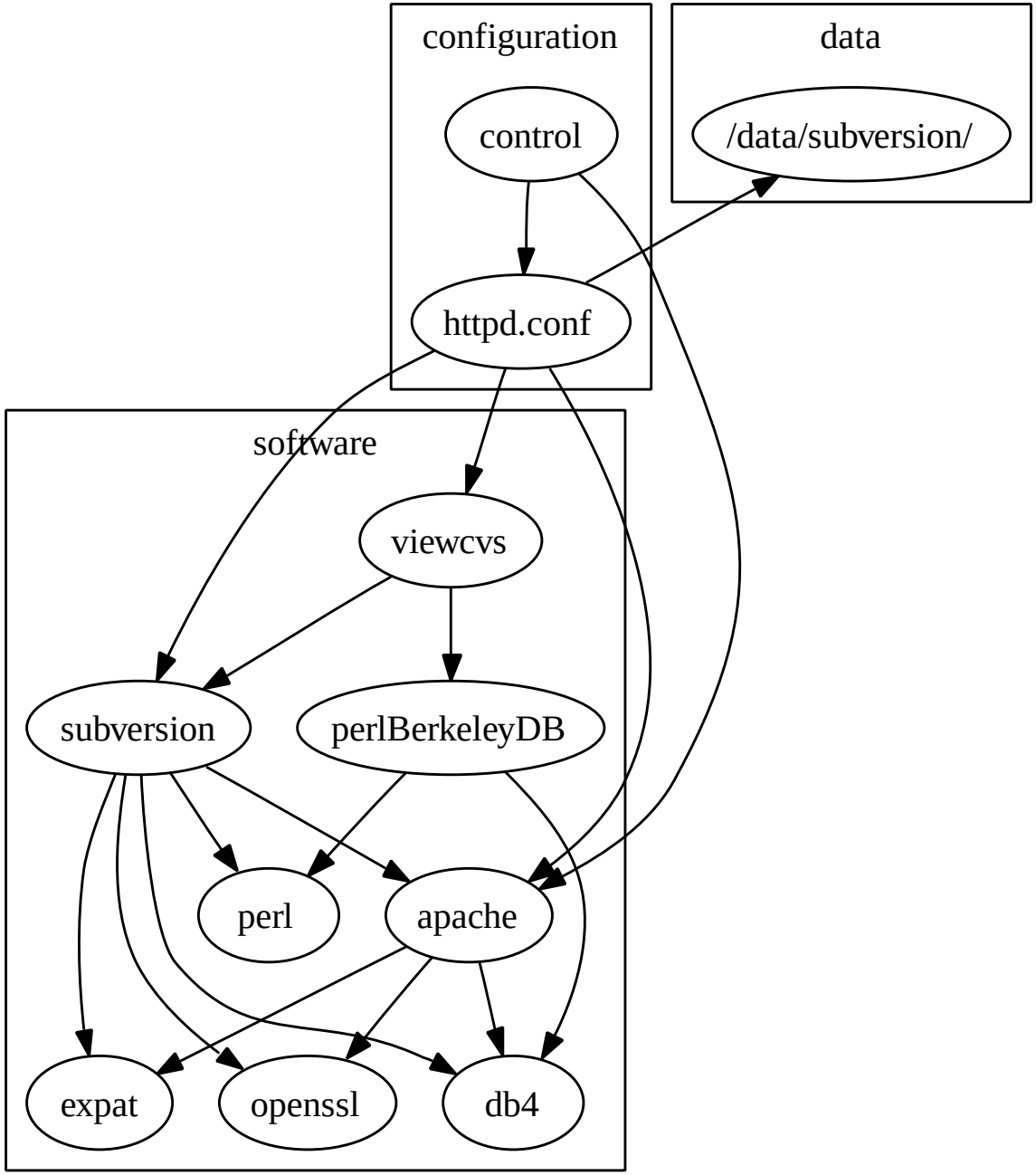
Problems

- Poor reproducibility (bad CM)
- Hard to support parallel configurations
- Cross-cutting configuration choices

Problem 1: Poor reproducibility

- Goal: it should be possible to realise a service by running a single command.
  - E.g., to move it to another machine
  - So no manual installing of missing software components, tweaking of configuration files, creating missing directories, etc.
- Why is reproducibility hard?
  - Admins often manually edit configuration files and initialise state
  - Service configuration doesn't express software component dependencies

Example


configuration
control
httpd.conf
data
/data/subversion/
software
viewcvs
subversion
perlBerkeleyDB
perl
apache
expat
openssl
db4

Gap between package management and service configuration

- Software components are typically deployed through package managers such as RPM
- Service configuration is typically kept under version management
- However, there is no good way to express the dependencies of the service on the software components

Problem 2: Parallel configurations

- It should be easy to create different instances of a service
  - Test vs. production servers (running on different ports, using different databases, etc.)
  - Instantiations for different users
  - Evolution through time (rollbacks)
- This is hard to support because there are typically lots of configuration files and control scripts that refer to lots of paths for components, state, static data files, etc.
  - **/etc/apache/httpd.conf**, **/etc/init.d/apache**, **/etc/apache/viewcvs.conf**, ...

Example

/etc/apache/httpd.conf for Subversion service (fragment)

```
ServerRoot "/var/httpd"
ServerName svn.cs.uu.nl:8080
LoadModule dav_svn_module /usr/lib/modules/mod_dav_svn.so
<Location /repos>
    AuthType Basic
    AuthDBMUserFile /data/subversion/db/svn-users
    ...
    SVNParentPath /data/subversion/repos
</Location>
ScriptAlias /viewcvs /usr/viewcvs/www/cgi/viewcvs.cgi
```

Example

/etc/init.d/httpd for Subversion service (fragment)

```
/usr/sbin/apachectl -k start -f /etc/apache/httpd.conf
```

Use cases

- Try out with a different set of repositories.
- Try out a different Apache.
- Try out a different Subversion module.

Problem 3: Cross-cutting configuration choices

- Many configuration choices are *cross-cutting*, i.e., impact many different (parts of) configuration files, scripts, etc.
- Examples:
  - Port numbers
  - Host names
  - Paths (major source of problems!)
- So a change to the configuration choices must be realised in many different places
- Lots of work
- Danger of inconsistency

Example: port number

In /etc/init.d/httpd.conf

```
ServerName www.example.org:12443
Listen 12443
<VirtualHost _default_:12443>
```

In repoman.pl

```
my $url = "https://www.example.org:12443/"
print "... <a href='$url/repos/$repoName'> ...";
```

Solution

Treat all the *static parts* of configurations as Nix components:

- Software
- Configuration files
- Control scripts
- Static data files (e.g., static web pages)

But not mutable state, e.g.,

- Databases

Continuous Integration and Release Management

- Building releases of components automatically involves many steps:
  - Prepare the build environment(s)
  - Make sure that all tests succeed
  - Build a source distribution
  - Build binary distributions for a variety of platforms
  - Upload (publish) to a server
  - Update client machines
- $\Rightarrow$ Requires a build farm.

Build farm

Set of machines that automatically performs build actions from a version management repository.
Nix is very useful for implementing a build farm:

- The Nix expression language is ideal for describing the build tasks.
- The Nix expression language makes it easy to describe variants.
- Nix manages the dependencies.
- Complete dependencies, thus reproducibility.
- Efficiency: only rebuild things that have actually changed.
- Builds can be made available through a channel.

Example

Release Index

Name	Type	Release	Date
bibtex-tools			
	Stable	*none*	
	Unstable	bibtex-tools-0.2pre7402	2004-09-17 21:26:47 UTC
		bibtex-tools-0.2pre7284	2004-09-01 13:22:25 UTC
		bibtex-tools-0.2pre7279	2004-08-29 13:50:24 UTC
		bibtex-tools-0.2pre7271	2004-08-28 20:52:28 UTC
		bibtex-tools-0.2pre7265	2004-08-28 12:51:01 UTC
		bibtex-tools-0.2pre7264	2004-08-28 12:09:18 UTC
	Failed	*none*	
dryad			
	Stable	*none*	
	Unstable	dryad-0.1pre7430	2004-09-20 16:08:36 UTC
	Failed	*none*	
java-borg			
	Stable	*none*	
	Unstable	java-borg-0.1pre7589	2004-10-04 18:35:45 UTC
	Failed	java-borg-0.1pre7604	2004-10-06 12:28:51 UTC
		java-borg-0.1pre7599	2004-10-05 13:35:40 UTC
		java-borg-0.1pre7575	2004-10-04 09:31:51 UTC
java-front			
	Stable	java-front-0.5	2004-10-04 16:26:41 UTC
	Unstable	java-front-0.6pre7587	2004-10-04 18:20:04 UTC
		java-front-0.5pre7564	2004-10-04 10:21:18 UTC
		java-front-0.5pre7511	2004-09-29 09:07:55 UTC

Example

java-borg release java-borg-0.1pre7604

This is a *bad* release: one or more of its build steps failed. See below for details. This release should not be used for production purposes.

This page provides release **java-borg-0.1pre7604** of java-borg. It was generated automatically on 2004-10-06 12:28:20 UTC from revision 7604 of the path /java-borg/trunk of its Subversion repository (the XML record of the build job is available).

Distribution

Source distribution

RPM for Red Hat 9.0

Problems

In case of build or usage problems with this release, please first check if there are newer releases that solve the problem. Otherwise report problems to stratego@cs.uu.nl, mentioning the full version number and a description of the platform you are building on. In case of a build problem include the part of the build log showing the error. In case of a usage problem try to narrow down the problem as much as possible and include enough information to reproduce the error.

Build Logs

Build of the Source Tarball [FAILED]

- Phase 0_unpack (raw)
- Phase 1_configure (raw)
- Phase 2_dist (raw) [FAILED]

Example

```
+ make[1]: Entering directory `/tmp/nix-1005-1/svn-export/syn'
+ building Swul.rtg
- building distdir
  - make[1]: Entering directory `/tmp/nix-1005-1/svn-export/trans'
    /bin/sh ../mkinstalldirs ../java-borg-0.1pre7604/trans/..
    list='java-xml java-java java-tuple swul'; for subdir in $list; do \ if test
    "$subdir" = .; then :; else \ test -d ../java-borg-0.1pre7604/trans/$subdir \ ||
    mkdir ../java-borg-0.1pre7604/trans/$subdir \ || exit 1; \ (cd $subdir && \ make
    \ top_distdir="." \ distdir=../../java-borg-0.1pre7604/trans/$subdir \ distdir)
    \ || exit 1; \ fi; \ done
    + make[2]: Entering directory `/tmp/nix-1005-1/svn-export/trans/java-xml'
    + make[2]: Entering directory `/tmp/nix-1005-1/svn-export/trans/java-java'
    + make[2]: Entering directory `/tmp/nix-1005-1/svn-export/trans/java-tuple'
    - make[2]: Entering directory `/tmp/nix-1005-1/svn-export/trans/swul'
      Makefile:771: no file name for `include'
      + building parse-swul.c
      - building swul-assimilate.c
        /...-strategoxt-0.12/bin/strc -I /...-strategoxt-0.12/share/xtc -I
        /...-java-front-0.5pre7381/share/java-front -I
        /...-java-front-0.5pre7381/share/sdf/java-front -I ../../syn/swul -I
        ../../sig --main io-swul-assimilate -i swul-assimilate.str -o
        swul-assimilate.c -c
        compiling swul-assimilate.str
        sglr:error: Parse error in ./swulc.str, line 40, col 15: character ':'
        unexpected
        /...-strategoxt-0.12/bin/parse-stratego: rewriting failed
        parse error in FILE("./swulc.str")
        compilation failed (0.47 secs)
        make[2]: *** [swul-assimilate.c] Error 1
        make[2]: Leaving directory `/tmp/nix-1005-1/svn-export/trans/swul'
    make[1]: *** [distdir] Error 1
    make[1]: Leaving directory `/tmp/nix-1005-1/svn-export/trans'
make: *** [distdir] Error 1
```

Example

java-borg release java-borg-0.1pre7589

This page provides release **java-borg-0.1pre7589** of java-borg. It was generated automatically on 2004-10-04 18:34:42 UTC from revision 7589 of the path /java-borg/trunk of its Subversion repository (the XML record of the build job is available).

Distribution

Source distribution

- `java-borg-0.1pre7589.tar.gz` (5313007 bytes; MD5 hash: `90b5c5c47f710fc8d2df75461a9c8a54`)

RPM for Red Hat 9.0

- `java-borg-0.1pre7589-1.i386.rpm` (5414534 bytes; MD5 hash: `2fabf0166d49d574f2db9654065d7940`)
- `java-borg-0.1pre7589-1.src.rpm` (5217845 bytes; MD5 hash: `d92746f9f97726e43a228e1ba48e6564`)

This RPM requires that the following packages are also installed:

- aterm-2.2-1.i386-redhat9.0-linux-gnu.rpm
- sdf2-bundle-2.2.i386-redhat9.0-linux-gnu.rpm
- strategoxt-0.12-1.i386-redhat9.0-linux-gnu.rpm
- java-front-0.5pre7390-1.i386.rpm

Nix Packages

This release can be installed through Nix, a system for software deployment. It has been built for the following platforms:

- *i686-linux*

You can install this package and keep it up to date by subscribing to the channel java-borg-unstable by once executing

```
$ nix-channel --add http://catamaran.labs.cs.uu.nl/dist/stratego/channels/java-borg-unstab
$ nix-channel --update
$ nix-env -i java-borg-0.1pre7589
```

Conclusions

- Contributions:
  - Safe, automatic coexistance of versions/variants.
  - Reliable dependencies.
  - Multiple concurrent configurations.
  - Atomic upgrades/rollbacks.
  - Safe garbage collection.
  - Binary deployment is automatic.
  - Can accomodate many deployment policies.
  - Useful for service deployment.
  - Integrated continuous integration / release management.
- Available at `http://www.cs.uu.nl/groups/ST/Trace/Nix`.

Further reading

ICSE'04 E. Dolstra, E. Visser, and M. de Jonge, *Imposing a Memory Management Discipline on Software Deployment*

LISA'04 E. Dolstra, M. de Jonge, and E. Visser, *Nix: A Safe and Policy-Free System for Software Deployment*

CBSE'05 E. Dolstra, *Efficient Upgrading in a Purely Functional Component Deployment Model*

ASE'05 E. Dolstra, *Secure Sharing Between Untrusted Users in a Transparent Source/Binary Deployment Model*

PhD thesis E.Dolstra, *The Purely Functional Software Deployment Model*