Service Configuration Management

SCM-12

Eelco Dolstra Martin Bravenboer Eelco Visser
{**eelco, martin, visser**}**@cs.uu.nl**

Universiteit Utrecht, Faculty of Science,
Department of Information and Computing Sciences

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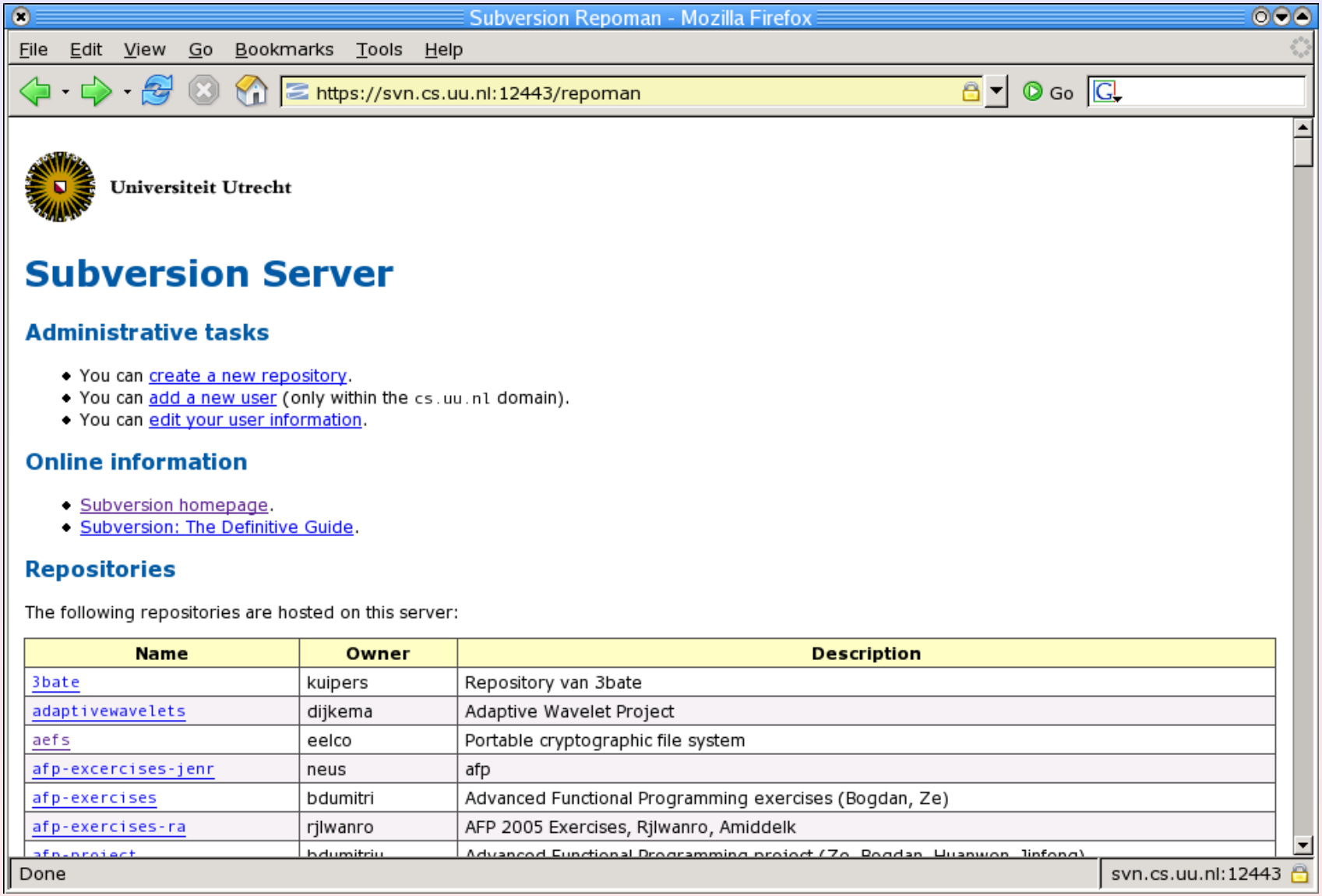
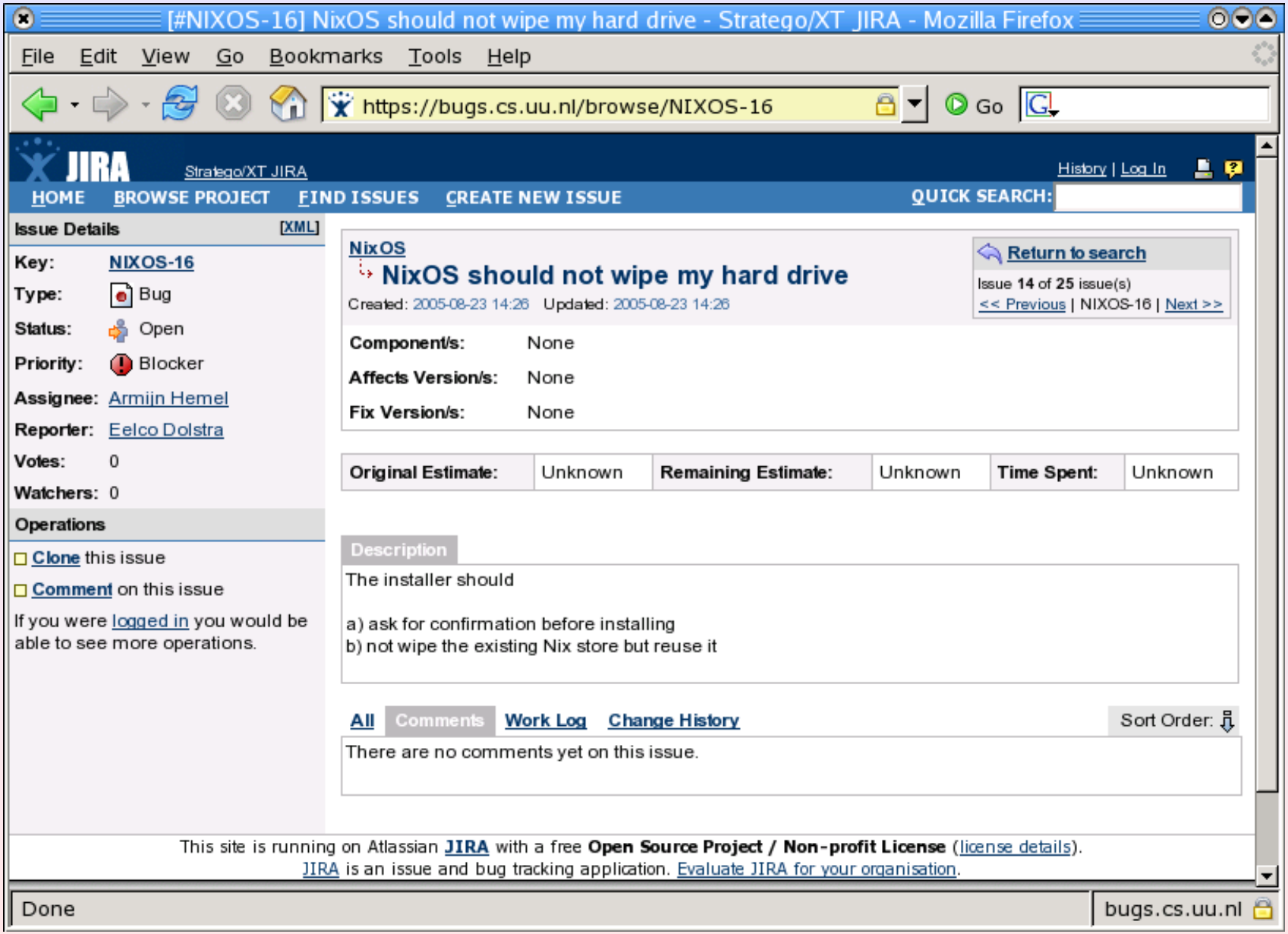
Service deployment

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

Example: Subversion service



Example: Issue tracking service



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

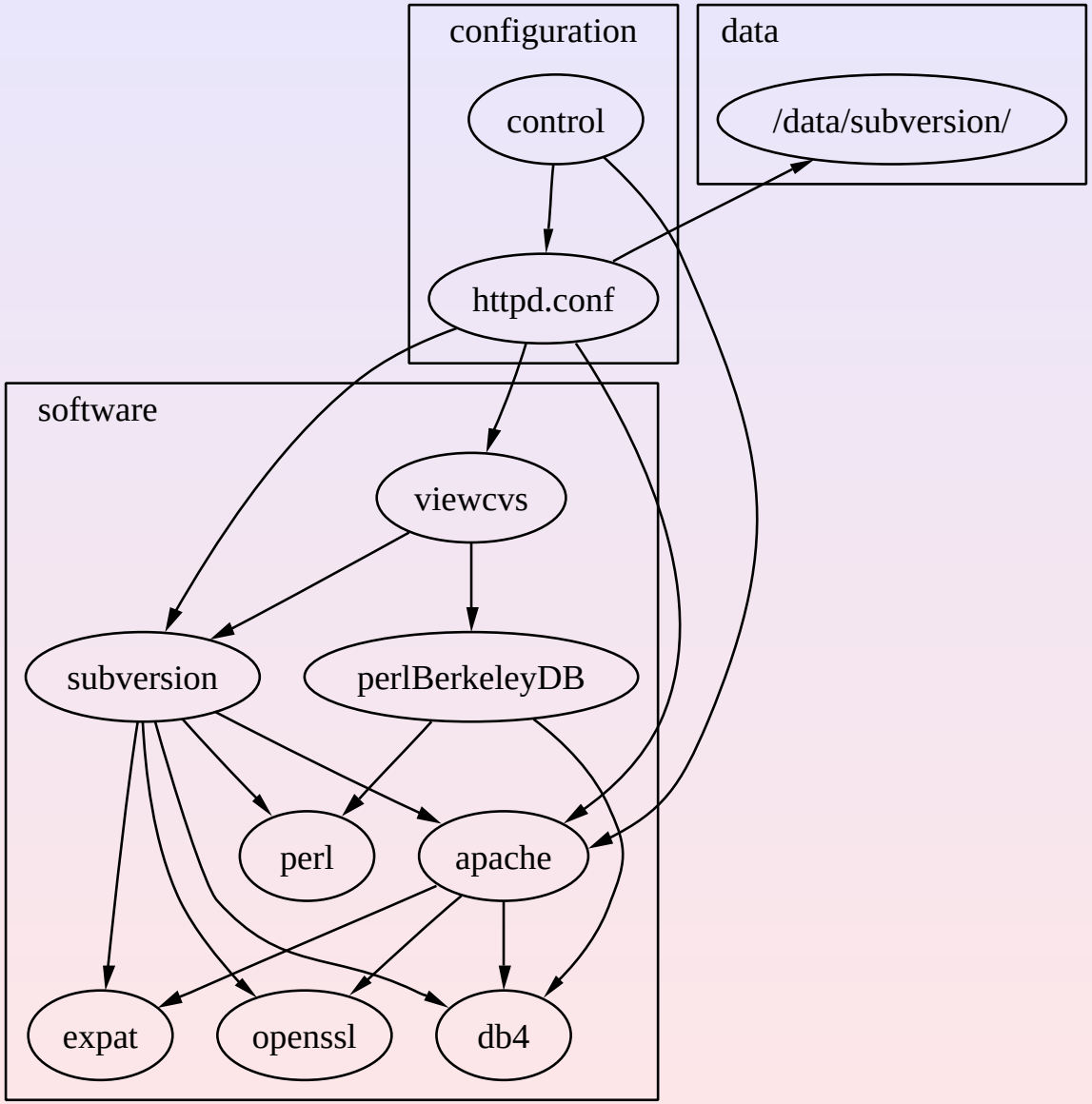
Problems

- 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
data
control
/data/subversion/
httpd.conf
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
```

Use cases

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

Example

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

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

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'> ...";
```

The solution

- The solution: integrate build management, software deployment, and service deployment into a single formalism
- Namely, the *Nix* deployment system
- Nix was originally created for *software deployment*
- Nice properties:
  - Automatic building of components and their dependencies
  - Side-by-side deployment, rollbacks
  - Prevention of undeclared dependencies, automatic determination of runtime dependencies
  - Functional component description language
- All these are also useful for *service deployment*
- Central idea of this paper: *treat services as components*

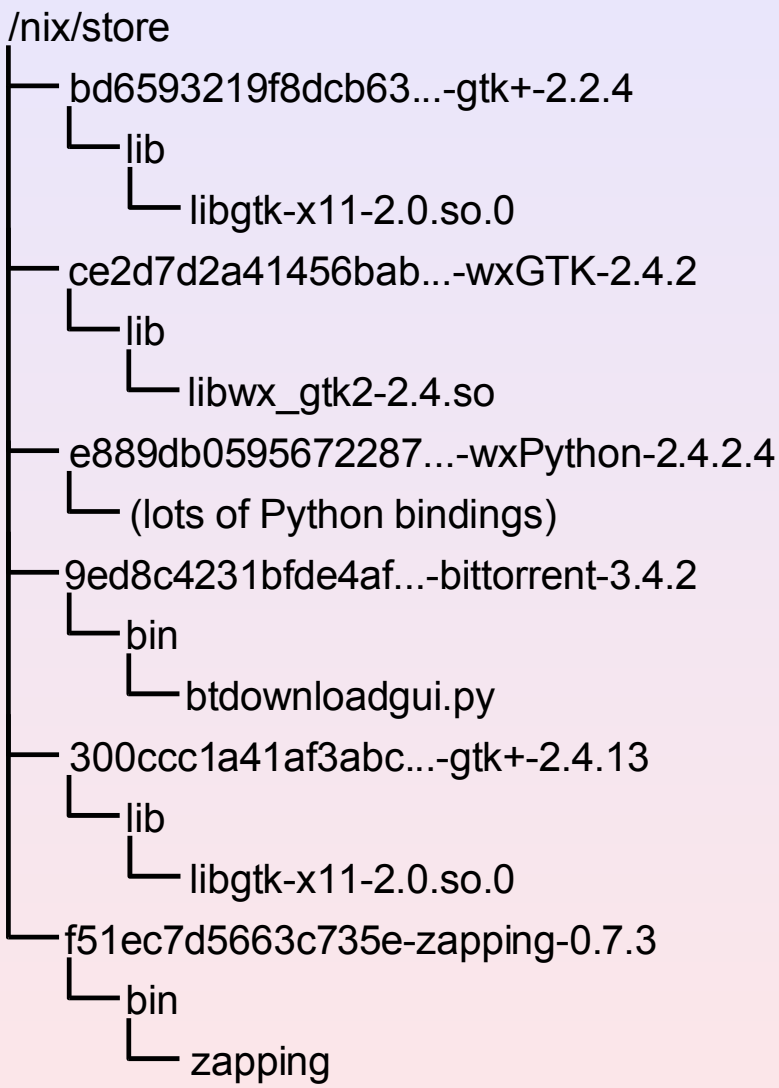
The Nix Deployment System

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

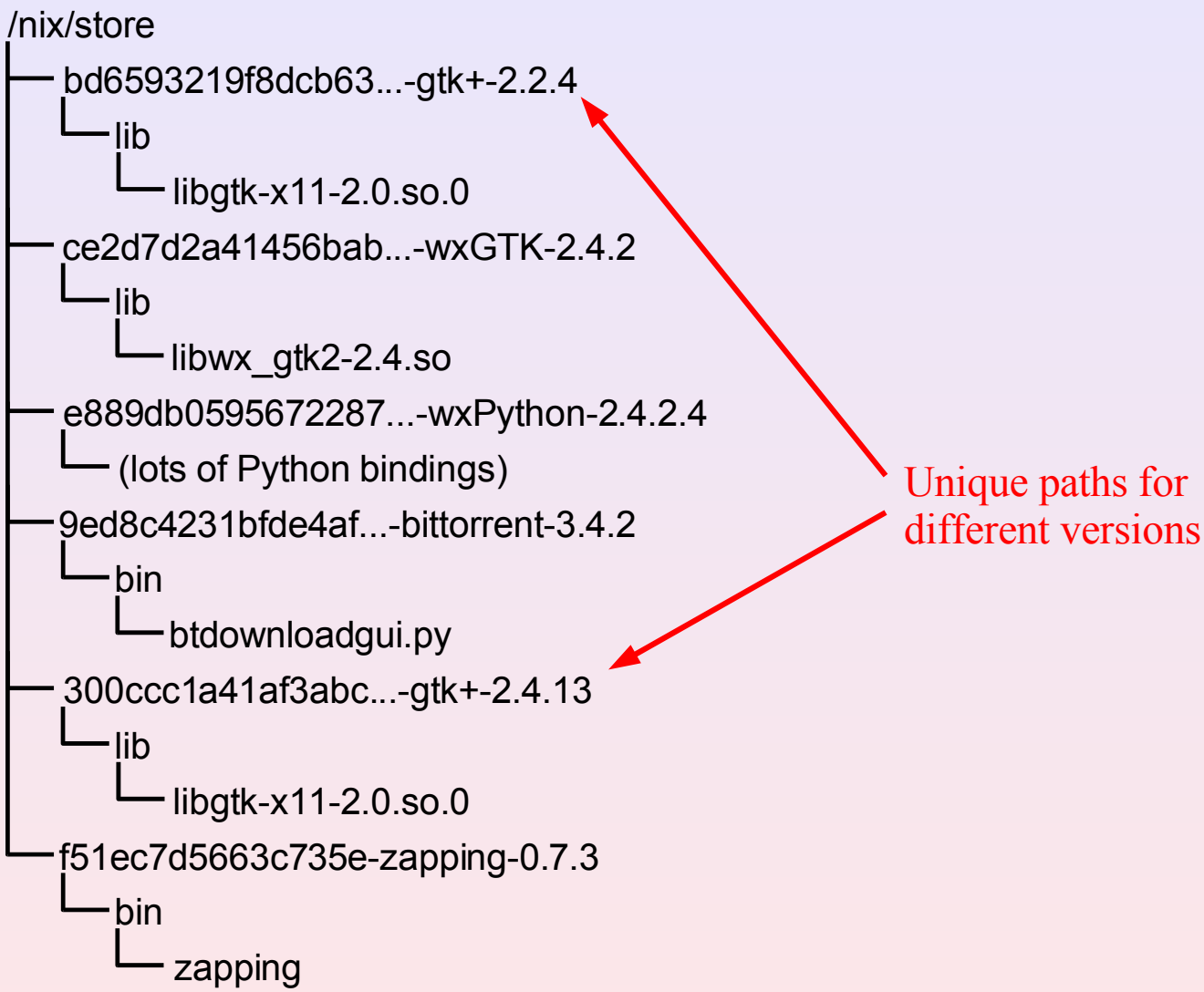
```
/nix/store/605332199533e73b...-gtk+-2.2.4
```

  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
libgtk-x11-2.0.so.0
f51ec7d5663c735e-zapping-0.7.3
bin
zapping

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
libgtk-x11-2.0.so.0
f51ec7d5663c735e-zapping-0.7.3
bin
zapping
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

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;
}
```

Function arguments

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;
}
```

Function arguments

Build attributes

Nix expressions

hello/builder.sh

```
. $stdenv/setup

PATH=$perl/bin:$PATH

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

Nix expressions

hello/builder.sh

```
. $stdenv/setup

PATH=$perl/bin:$PATH

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

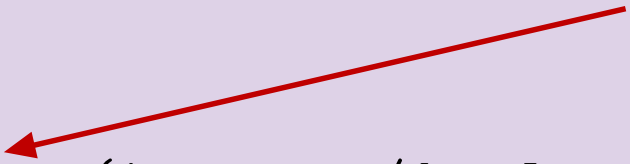
system/all-packages-generic.nix

```
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 = ...;
```



Back to service deployment

We're just going to build service configuration files and control scripts as software components, i.e., as immutable objects in the Nix store.

Back to service deployment

services/svn.nix

```
{ stdenv, apacheHttpd, subversion }:
stdenv.mkDerivation {
  name    = "svn-service";
  builder = ./builder.sh; # Build script.
  control = ./control.in; # Control script template.
  conf    = ./httpd.conf.in; # Apache configuration template.
  inherit apacheHttpd subversion;
}
```

Back to service deployment

services/httpd.conf.in

```
...
LoadModule dav_svn_module
    @subversion@/modules/mod_dav_svn.so
...
```

Back to service deployment

services/control.in

```
#! @shell@/bin/sh
...
@apacheHttpd@/sbin/apachectl -k start
  -f @out@/httpd.conf
...
```

Back to service deployment

services/builder.sh

The builder just replaces **@subversion@**, **@apacheHttpd@**, etc., with the actual paths of the components in the Nix store (passed as arguments to the function).

Using the service

Building and starting

```
# upgrade-server svn ./svn.nix
```

Upgrading and restarting

Idem

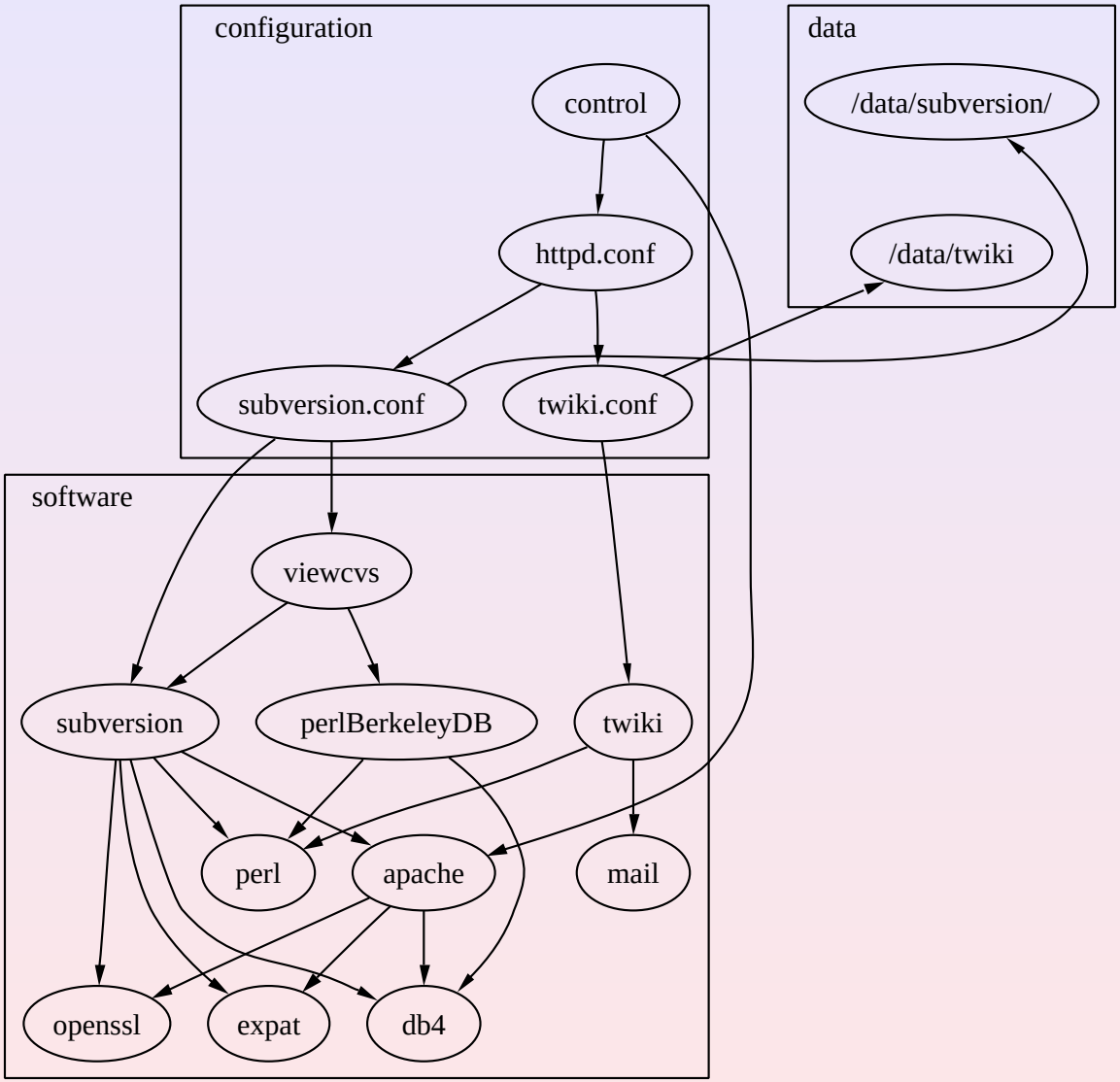
Rollback

```
# /nix/var/nix/profiles/svn-service/bin/control stop
# nix-env -f /nix/var/nix/profiles/svn-service --rollback
# /nix/var/nix/profiles/svn-service/bin/control start
```

Modularity

- The previous service is *monolithic*: the Apache instance provides only the Subversion service.
- In general it should be possible to run multiple services ("subservices") within a web server, database server, etc.
- Therefore the previous service should be split into:
  - An Apache service
  - A list of *subservices* that plug into Apache

Example


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

Example — combined Subversion / TWiki server

```
subversionService = import ../subversion-service {
  httpPort = 80;
  reposDir = "/data/subversion"; ...
};
twikiService = import ../twiki-service {
  twikisDir = "/data/twiki"; ...
};
webServer = import ../apache-httpd {
  inherit (pkgs) stdenv apacheHttpd;
  hostName = "svn.cs.uu.nl";
  httpPort = 80;
  subServices = [subversionService twikiService];
};
```

Example — combined Subversion / TWiki server

```
subversionService = import ../subversion-service {
  httpPort = 80; # Oops!
  reposDir = "/data/subversion"; ...
};
twikiService = import ../twiki-service {
  twikisDir = "/data/twiki"; ...
};
webServer = import ../apache-httpd {
  inherit (pkgs) stdenv apacheHttpd;
  hostName = "svn.cs.uu.nl";
  httpPort = 80; # Oops!
  subServices = [subversionService twikiService];
};
```

Cross-cutting configuration

- The Nix expression language is functional, which makes it easy to define cross-cutting configuration choices once and propagate them to their realisation sites.
- This also makes it easy to express variability in configurations.
  - E.g., whether to build a test or production server
  - Due to hashing any change to the configuration will result in the resulting components stored in a different location in the Nix store

Example

```
{productionServer}: # Variation point
let {
  port = if productionServer then 80 else 8080;
  webServer = import ./apache-httpd {
    inherit (pkgs) stdenv apacheHttpd;
    hostName = "svn.cs.uu.nl";
    httpPort = port;
    subServices = [subversionService twikiService];
  };
  subversionService = import ./subversion-service {
    httpPort = port;
    reposDir = "/data/subversion"; ...
  };
  twikiService = import ./twiki-service {
    twikisDir = "/data/twiki"; ...
  };
}
```

Distributed services

- Services frequently consist of subservices running on different machines / platforms

Distributed services

- Nix already supports multi-platform distributed builds, semi-transparently:

```
derivation {
  name = "foo";
  builder = ./builder.sh;
  system = "i686-linux"; ... }
```

  Attribute system denotes platform for component build action; if machine is not **i686-linux**, the build will be forwarded to a machine of the right type.

- *Starting* and *stopping* is done by a *service runner* component that remotely starts/stops subservices on the machines identified by their **host** attributes.

Example

PostgreSQL server on FreeBSD

```
# Build a Postgres server on FreeBSD.
postgresService = import ./postgresql {
  inherit (pkgsFreeBSD) stdenv postgresql;
  host = "losser.labs.cs.uu.nl"; # Machine to run on.
  dataDir = "/var/postgres/jira-data";

  subServices = [jiraService];
  allowedHosts = [jettyService.host]; # Access control.
};
```

Example (cont'd)

Jetty container on Linux

```
# Build a Jetty container on Linux.
jettyService = import ./jetty {
  inherit (pkgsLinux) stdenv jetty j2re;
  host = "itchy.labs.cs.uu.nl"; # Machine to run on.

  # Include the JIRA web application at URI path.
  subServices = [ { path = "/jira"; war = jiraService; } ];
};

# Build a JIRA service.
jiraService = import ./jira/server-pkgs/jira/jira-war.nix {
  inherit (pkgsLinux) stdenv fetchurl ant postgresql_jdbc;
  databaseHost = postgresService.host;  # Database to use.
};
```

Example (cont'd)

Service runner on Linux

```
# Compose the two services.
serviceRunner = import ./runner {
  inherit (pkgsLinux) stdenv substituter;
  services = [postgresService jettyService];
};
```

Related work

- Package management tools (e.g., RPM)
  - Don't do service configuration
- Build managers
  - Make: doesn't deal with variability very well
  - Better build managers: Odin, Vesta; these have better variability support
- Cfengine (Burgess 1995)
  - Specification of *destructive* action to be performed to realise a desired target state
  - E.g., add lines X to configuration file Y
  - Destructive model and lack of abstraction over paths makes it hard to support multiple instances of a service
  - Disconnect from software deployment

Conclusion

- Nix's properties for software deployment carry over to service deployment
- I.e., full dependencies ($\Rightarrow$ reproducibility), automatic builds, side-by-side deployment of variants, rollbacks
- Nix expression language is good for dealing with cross-cutting configuration choices
- Approach extends to distributed deployment

Links

- Homepage: `http://www.cs.uu.nl/groups/ST/Trace/Nix`
- Installation instructions for the Subversion service: `https://svn.cs.uu.nl:12443/repos/trace/services/trunk/subversion/INSTALL`