Continuous Integration and Release Management with Nix

Eelco Dolstra

Institute of Information & Computing Sciences
Utrecht University, The Netherlands

July 14, 2004

Outline

Outline

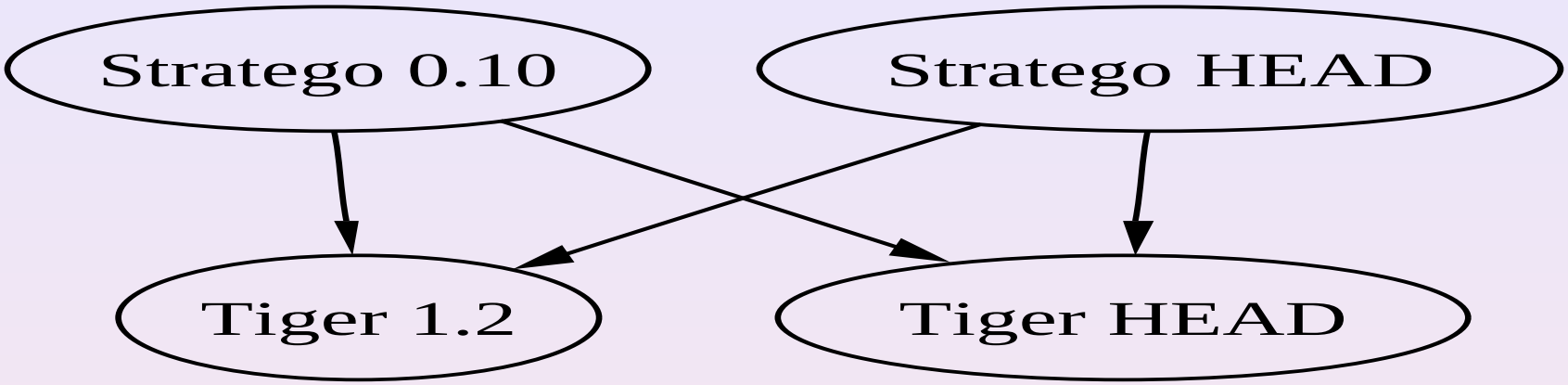
Continuous Integration

- When developing multiple components of a system in parallel, we must *integrate* them at some point.
- "Integrate often" is more effective than "Big-Bang Integration".
- So compositions of components should be built as often as possible.
- $\Rightarrow$ Requires a build farm.

Example

- Stratego/XT is a compiler/toolset for the Stratego program transformation language.
- Tiger is a compiler for the Tiger language, written in Stratego.
- The Stratego/XT developers want to know:
  - Whether Stratego/XT builds on/in a variety of platforms / configurations.
    - E.g., GCC 3.3 vs. GCC 3.4, SDF 2.2 vs SDF 2.3
  - Whether changes to the Stratego compiler breaks existing Stratego code.
- The Tiger developers want to know:
  - Whether Tiger builds on/in a variety of platforms / configurations.
  - Whether Tiger is compatible with previous/current releases of Stratego/XT, and with the HEAD branch.

Example



The advantages:

- Tiger acts as a real-world regression test for Stratego/XT.
- Stratego/XT developers get feedback about unintentional breakage in the HEAD.
- Tiger developers get early feedback about incompatible changes to Stratego/XT.

Outline

Release Management

- We want to build releases of components...
- ... automatically, since many steps are involved, e.g.,
  - Make sure that all tests succeed.
  - Build a source distribution.
  - Build binary distributions for a variety of platforms.
  - Upload (publish) to a server.
  - Announce the release on a mailing list.
- $\Rightarrow$ Requires a build farm.

Outline

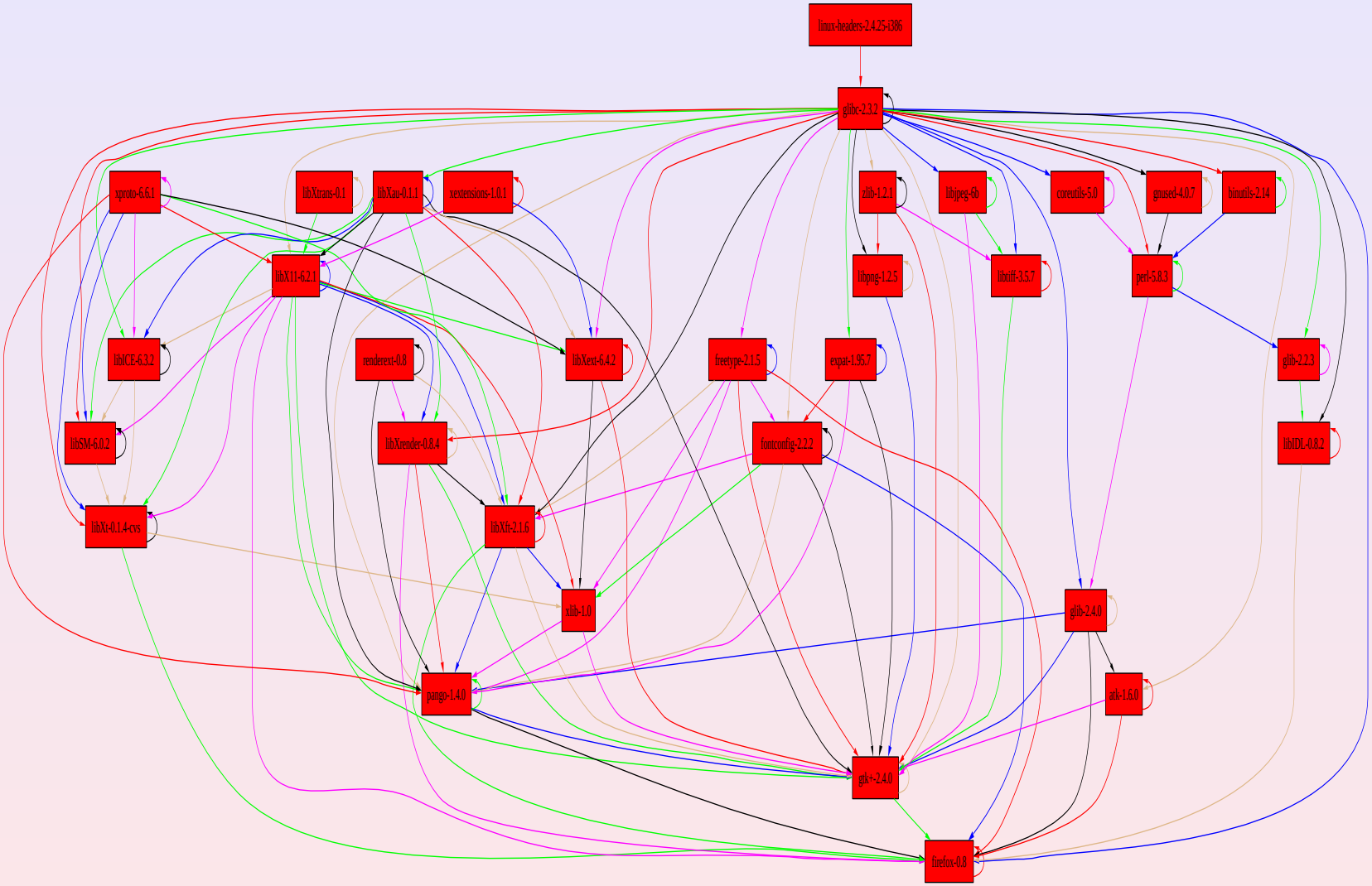
Other Advantages of Build Farms

- Allows more tests than can feasibly be run by a developer prior to commit:
  - Build on multiple platforms.
  - Build multiple configurations / variants.
  - Run time-consuming test sets.
- Distribute pre-built components to other developers.

Current Build Farms

- Mozilla Tinderbox, Cruise Control, AutoBuild, ...
- Disadvantages:
- Typically build single components, not compositions.
- Do not manage dependencies:
  - E.g., "package X requires GCC 3.3, GTK 2.4, Bison 1.875c, ..."
  - This is left to the sysadmin of the build farm machines.
  - But dependencies can conflict: "package Y does *not* build on GCC 3.3".
  - And dependencies can evolve: "package X now requires GCC 3.4" $\Rightarrow$ requires $\Theta(n)$ sysadmin time.

Dependency Hell



Outline

Nix: A System for Software Deployment

- Nix is a system for *software deployment*, i.e., for distributing software from the developer to the user.
- Features:
  - Correctness: complete deployment. No missing dependencies—Nix always deploys *closures* of components.
  - Support for multiple versions/variants of components.
  - Users can have different versions/variants installed at the same time.
  - Automatic garbage collection of unused components.
  - Atomic upgrades / rollbacks.
  - Simple language for describing components and compositions.
  - Transparant source/binary deployment.
    - Basic model is source deployment, with binary deployment as a transparent optimisation.

Nix Expressions

- Nix expressions describe how components and compositions can be built.
- Simple functional language.

Nix expression for Stratego/XT: `strategoxt.nix`

```
{stdenv, fetchurl, aterm, sdf}:
 stdenv.mkDerivation {
  name = "strategoxt-0.10";
  builder = ./builder.sh;
  src = fetchurl {
    url = ftp://.../strategoxt-0.10.tar.gz;
    md5 = "526a28e84248b649bb098b22d227cd26";
  };
  inherit aterm sdf;
}
```

Nix Expressions

- Nix expressions describe how components and compositions can be built.
- Simple functional language.

Build script for Stratego/XT: `builder.sh`

```
tar xvfz $src
cd strategoxt-*
./configure --prefix=$out \
  --with-aterm=$aterm \
  --with-sdf=$sdf
make
make install
```

Nix Expressions

- Nix expressions describe how components and compositions can be built.
- Simple functional language.

Composition: composition.nix

```
let {
  stdenv = import (...)/stdenv.nix;
  aterm = (import (...)/aterm.nix) {inherit stdenv;};
  sdf = (import (...)/sdf.nix) {inherit stdenv;};
  strategoxt = (import ./strategoxt.nix) {
    inherit stdenv aterm sdf;
  };
  body = strategoxt;
}
```

User Operations

To build and install Stratego/XT:

```
$ nix-env -if ./composition.nix strategoxt
```

When a new version comes along:

```
$ nix-env -uf ./composition.nix strategoxt
```

If it doesn't work:

```
$ nix-env --rollback
```

Delete unused components:

```
$ nix-collect-garbage
```

User Operations (Channels)

Subscribe to a channel:

```
$ nix-channel --add http://.../nix-stable-pkgs
```

Update all packages to the latest versions:

```
$ nix-channel --upgrade
```

Transparent Binary Deployment

On the producer side:

```
$ nix-push ./composition.nix http://server/cache
```

On the client side:

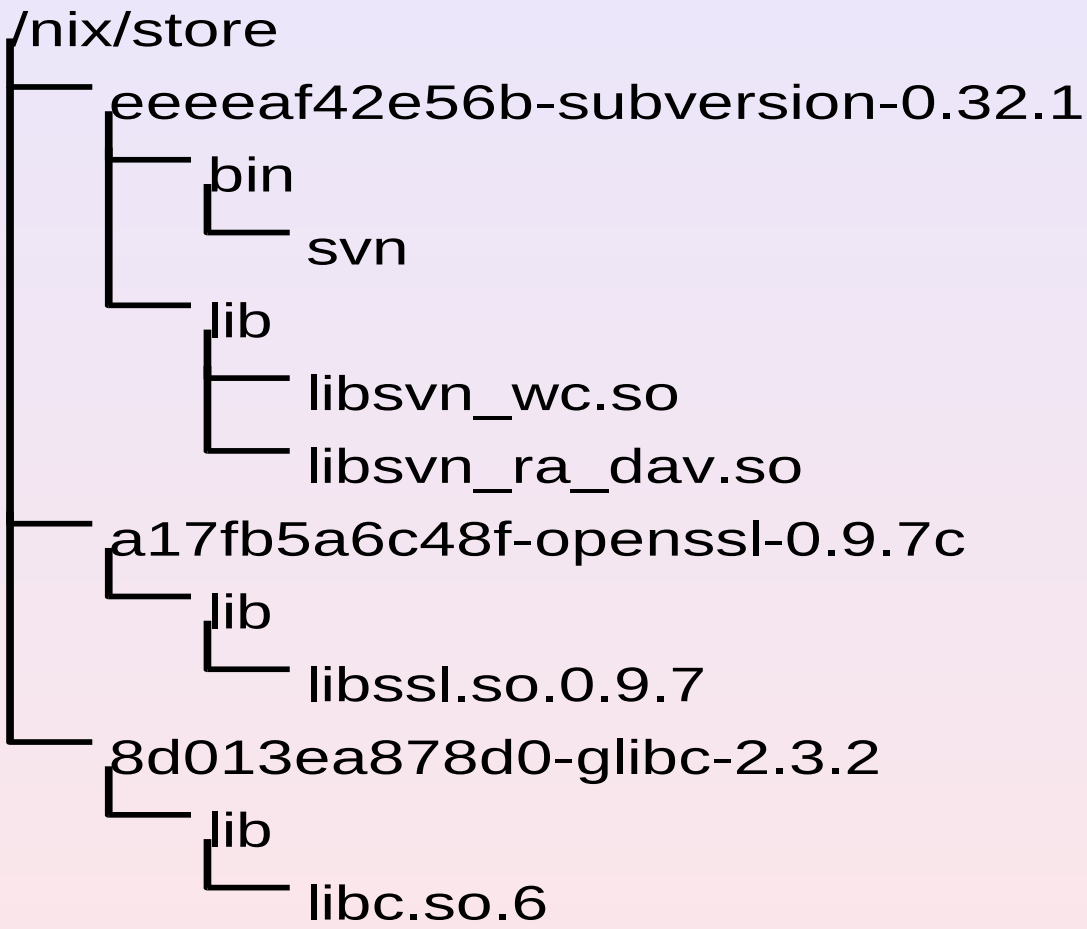
```
$ nix-pull http://server/cache
```

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

Implementation

- All packages are stored in isolation from each other in the file system (in subdirectories of the *Nix store*—typically `/nix/store`).
- Names of component directories contain a *cryptographic hash* of all inputs involved in building the component:
  - Input components (compilers, libraries, other tools).
  - Sources.
  - Build scripts.
  - Variability parameters.
  - System type on which the component is to be built.

Implementation



Outline

Implementing a Build Farm with Nix

So why is this useful for a build farm?

- The Nix expression language is ideal for describing the build tasks to be performed.
- The Nix expression language makes it easy to describe variant compositions.
- Nix manages the dependencies (and thus the build environment).
- Nix supports distributed builds in a semi-transparent way.
- The hashing scheme + complete dependencies allow builds to be reproduced reliably.
- Efficiency: due to the hashing scheme, we only rebuild things that have actually changed.

Making Stratego/XT Releases

What each release should contain:

- A source distribution.
- Binary distributions for a number of platforms. (Test sets should also be run on each platform).
- Build logs.

Making Stratego/XT Releases (2)

Building a source distribution

```
# Bring in some standard packages (compilers, etc.)
pkgs = (import .../all-packages);
pkgsLinux = pkgs {system = "i686-linux"};

strategoxtTarball = revision: svnToSourceTarball revision {
  stdenv = pkgsLinux.stdenv;
  buildInputs = [pkgsLinux.autoconf pkgsLinux.automake ...];
};
```

`svnToSourceTarball` is a function that checks out sources from a specific revision from a Subversion repository (as specified by `version`.

Making Stratego/XT Releases (3)

Building a binary distribution for Linux

```
strategoxtBinary = revision: buildBinary
  (strategoxtTarball revision)
{
  stdenv = pkgsLinux.stdenv;
  withATerm = pkgsLinux.aterm;
  withSDF = pkgsLinux.sdf;
};
```

`buildBinary` performs a build of a source distribution.

Making Stratego/XT Releases (4)

Building a release page

```
strategoxtRelease = revision: makeReleasePage {
  stdenv = pkgsLinux.stdenv;
  sourceTarball = strategoxtTarball;
  binaries = [strategoxtBinary];
};
```

makeReleasePage creates a bunch of HTML and other files that should be uploaded to a server.

Making Stratego/XT Releases (5)

Instantiating

```
strategoxtHeadRelease = strategoxtRelease {
  url = https://svn.cs.uu.nl/repos/StrategoXT/trunk;
  rev = (HEAD revision);
};

strategoxt010Release = strategoxtRelease {
  url = https://svn.cs.uu.nl/repos/StrategoXT/tags/0.10;
  rev = 6812;
};
```

Distributed Builds

- Nix expressions specify on what system a package is to be built.

```
derivation {
  name = "strategoxt-0.10";
  builder = ./builder.sh;
  system = "powerpc-darwin";
}
```

- Normally, if we build this on (say) a `i686-linux`:

```
$ nix-env -i foo.nix ...
error: I am a 'i686-linux', but a
'powerpc-darwin' is required to build this.
```

Distributed Builds

- Solution: we can configure Nix with a mapping from system types to machines (e.g., `powerpc-darwin` ⇒ `bigmac.cs.uu.nl`).
- If we then try to perform the build, Nix will:
  - Send all build inputs to `bigmac.cs.uu.nl`.
  - Run Nix on that machine to perform the build.
  - Copy back the result.
- Different subexpressions can require different system types (useful for build farms and cross-compilation).
- Builds are performed in parallel.

Making Stratego/XT Releases (5)

Building for Multiple Platforms

```
pkgs = (import .../all-packages);
pkgsLinux = pkgs {system = "i686-linux";};
pkgsDarwin = pkgs {system = "powerpc-darwin";};

strategoxtBinary = pkgs: revision: buildBinary
  (strategoxtTarball revision)
{
  stdenv = pkgs.stdenv;
  withATerm = pkgs.aterm;
  withSDF = pkgs.sdf;
};

strategoxtBinaries = revision: [
  (strategoxtBinary pkgsLinux revision)
  (strategoxtBinary pkgsDarwin revision)
];
```

Building Tiger Binaries

```
tigerTarball = ...;

tigerBinary = revision: strategoxt: buildBinary
  (tigerTarball revision)
{
  stdenv = pkgsLinux.stdenv;
  withStrategoXT = strategoxt;
};
```

Multiple Compositions

Building Tiger Binaries

```
tigerHeadRelease = strategoxtRelease {
  url = https://svn.cs.uu.nl/repos/tiger/trunk;
  rev = (HEAD revision);
};

tiger12Release = strategoxtRelease {
  url = https://svn.cs.uu.nl/repos/tiger/tags/1.2;
  rev = ...;
};
```

Multiple Compositions

Building Tiger Binaries

```
tigerBinaries = [
  (tigerBinary (tigerHeadRelease)
    (strategoxtBinary (strategoxtHeadRelease)))
  (tigerBinary (tigerHeadRelease)
    (strategoxtBinary (strategoxt010Release)))
  (tigerBinary (tiger12Release)
    (strategoxtBinary (strategoxtHeadRelease)))
  (tigerBinary (tiger12Release)
    (strategoxtBinary (strategoxt010Release)))
]
```

Multiple Compositions

Building Tiger Binaries

```
tigerBinaries =
  [ tigerBinary t s
  | t <- [tigerHeadRelease tiger12Release]
  , s <- [strategoxtHeadRelease strategoxt010Release]
  ];
```

Outline

Conclusion

The Nix build farm:

- Allows safe and efficient management of dependencies.
- Ensures reproducibility.
- Supports multi-platform builds.
- Is efficient: only changed things are rebuilt.
- Produces actual releases.

More information:
`http://www.cs.uu.nl/groups/ST/Trace/Nix`.