# Hashdist – Yet Another Desperate Attempt at Fixing Scientific Software Distribution

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Ondřej Čertík
Chris Kees

Simula, January 24, 2013

`http://github.com/hashdist`

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- Sometimes you **need** the very latest version
- Fortran/C++ instead of C/Java/.NET
- Intersection of “need speed” and “do not pay dedicated application sysadmins”

## Combinatorial explosion

```
/cluster/software/VERSIONS/hdf5-1.6.1/lib/libhdf5.so
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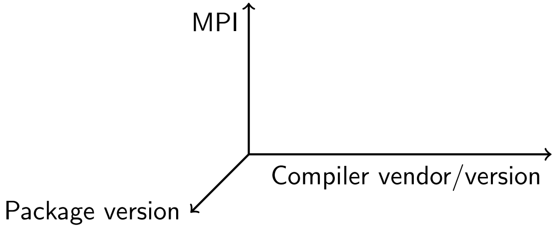

$\times$ LAPACK $\times$ FFT library $\times$ IDL/Python version...

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- HPC environment modules
  - The sysadmins hate them
  - The users need newer/their own libraries

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- The details are different for everybody

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- Debian, RedHat, cluster sysadmins, dorsal is all about curated software stacks
- Perhaps you want 60% curated, 20% bleeding edge or manually tweaked, 20% your own code...

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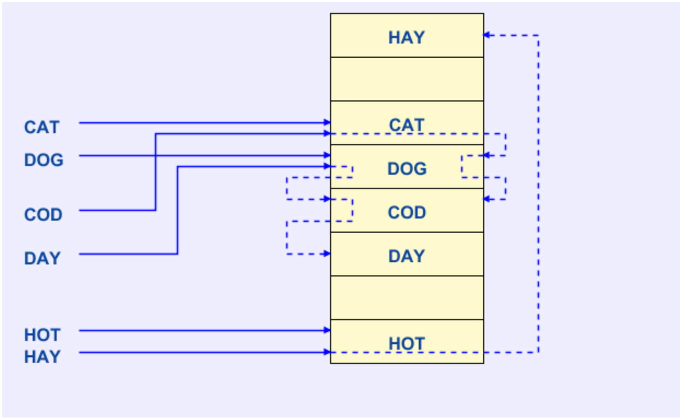
- Need to have new ideas

## Theory

## Hash function

$$h(k) : \mathbb{N} \to \mathbf{H}$$

## Digression – $O(1)$ hash table table lookups



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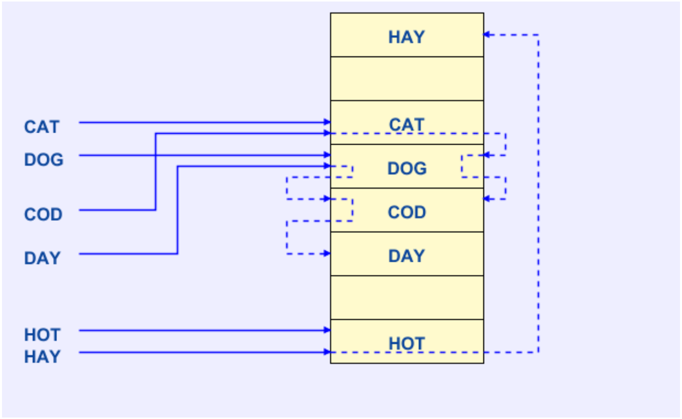

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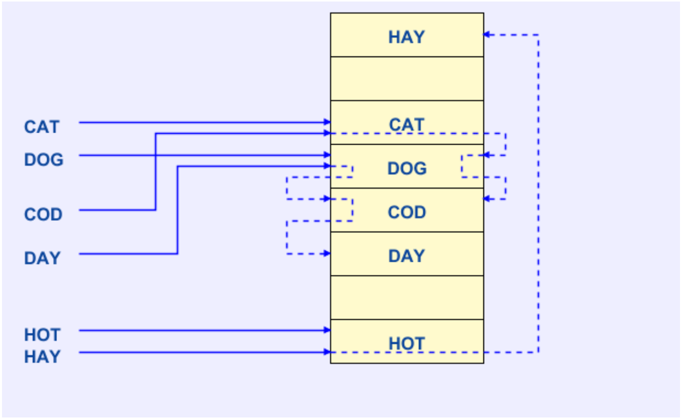

If you know contents up front: Create *perfect* $h$

$h$ should be very fast; don't care so much about properties

Image: Hopgood (1968), Computer Bulletin

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$h($`'The dark fox'`$) = h($546865206461726b20666f78 hex$)$
$=$ `b6589fc6ab0dc82cf12099d1c2d40ab994e8410c` hex

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$=$ `da4b9237bacccdf19c0760cab7aec4a8359010b0` hex

## Example 1: Store passwords

Use the one-way nature

## Example 2: git

```
$ (cd code/hashdist/.git/objects; find)
./59/5a2f8e3890d0ece24514f3e32ae874f1f03ac2
./2f/780151688e1f122a5b9072d42009c80c36140c
./2f/4b2eef40b51bc2d46027d1864653b37dd05f8f
./2f/237d74e3f81f498212629ac0b96bedac4b0b36
./2f/dff799c54fed6fe96a91e1d5f1593996228ebc
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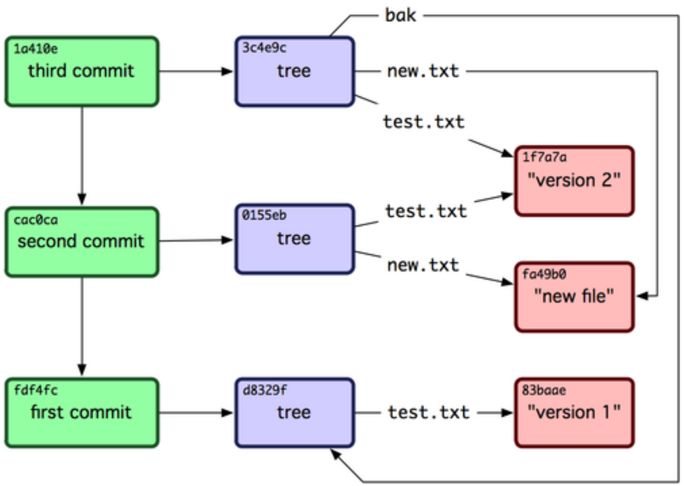

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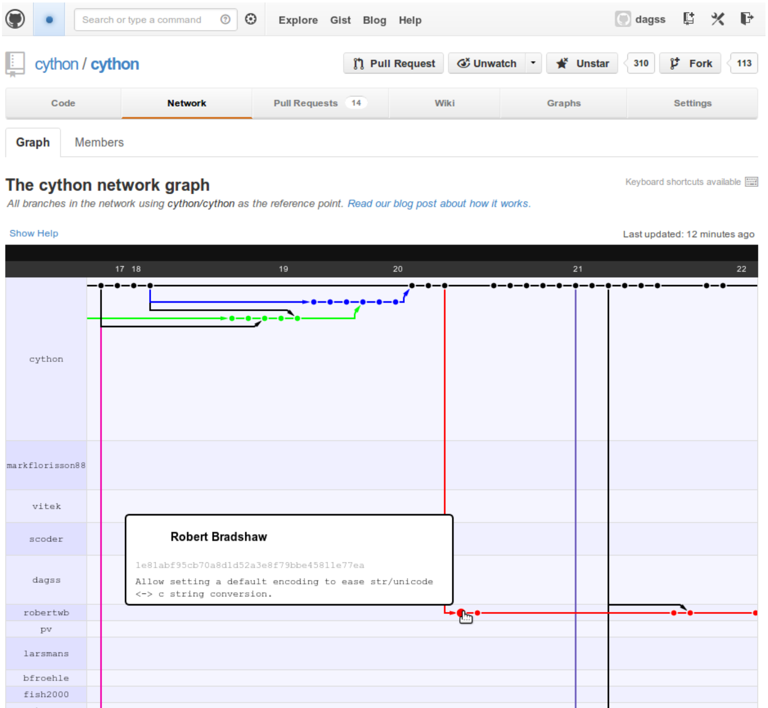
- ...but a hash simultaneously verifies the content!



The cython network graph

*All branches in the network using* cython/cython *as the reference point. Read our blog post about how it works.*

Robert Bradshaw

1e81abf95cb70a8d1d52a3e8f79bbe45811e77ea

Allow setting a default encoding to ease str/unicode <-> c string conversion.

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- Brute-force SHA-1 still needs only $2^{60}$ operations due to weaknesses in SHA-1
  - $2.5M today, $50K after 2020.

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  ```
  ~/.hit/opt/hdf5/efn3/lib/libhdf5.so
  ~/.hit/opt/hdf5/i7ni/lib/libhdf5.so
  ~/.hit/opt/hdf5/qgpd/lib/libhdf5.so
  ```
  (really `hdf5/efn3i7ni7lbtik4frlb5wcnqgpdmi3ql`)

## Step 1: Hash the build

**Internal protocol!**

```
{
   "name": "hdf5",
   "import" : [{ "id" : "gcc/apyicmxgafb564zz7rwhwvon7padvxdx"},
               { "id" : "unix/v-1"},
               { "id" : "zlib/wbg27phinbgwjg4nasb4xzf3ypo72otn"}],
   "sources" : [{ "key" : "tar.bz2:7jxgwn5xs5xnvsdaomvypridodr35or2"}],
   "cmd": ["sh", "$in0"],
   "inputs": [
       "text": [
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Hash to create key → `hdf5/fjczhadqtyx6jlbnvzlthrzsex7wz7xb`

## Step 2: Every build installs to separate location

Same as with the “module load“ system:

```
$ echo opt/*/*
opt/hdf5/avnj opt/hdf5/a5df opt/hdf5/a4sf opt/python/arxd
opt/python/rvdo opt/readline/6vvu  opt/readline/v7fw
opt/zlib/fh7n  opt/zlib/i7yr ...

$ ls opt/zlib/fh7n/lib
libz.a  libz.so  libz.so.1  libz.so.1.2.5  pkgconfig

$ ls opt/hdf5/avnj/lib
libhdf5.a  libhdf5.so  libhdf5.so.7  libhdf5.so.7.0.4
```

## Step 3: Make a profile with links

```
$ ls -la opt/profile/ldhn/bin
h5dump -> ../../../hdf5/avnj/bin/h5dump
h5import -> ../../../hdf5/avnj/bin/h5import
h5ls -> ../../../hdf5/avnj/bin/h5ls
...
```

## Branchable software stack

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-
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  ~/mystack $ hit update # instant
  ~/mystack $ ~/local/bin/python --version
  Python 2.6.3
  ```

## Consequences of hash-based installation

1. More dimensions! Even
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**Sophisticated features with simple implementation**

Prior art: Eelco Dolstra's PhD thesis/the Nix project

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- NP-complete problem, e.g.:
  - Integer linear programming
  - Belief propagation (from Bayesian network theory)

## Why bother?

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- Leaving build input variables free (e.g., LAPACK) allows "re-seating" a software stack description from one system to another
- Small step towards the "reproducible paper"

The end

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Some help:

- Integrate with host system (Debian, environment modules, “generic”) to specify dependencies on package on host system
- “hdist-jail” can issue warnings if a build process accesses files it shouldn’t (or hide them)

## User-facing software stack definitions

Declarative approach (because you can git it and share it):

```
include:
  - sources # pull in ./sources.yml
  - build
  - when cluster == "abel":
    - abel-overrides
profiles:
  - name: "default"
    configuration:
      lapack_type: "openblas"
      cluster: "hexagon"
    select:
      - project: "hdf5"
        version: 1.8.2
      - project: "h5py"
        ...
```

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    select:
      - project: "hdf5"
        version: 1.8.2 to 1.8.5 # with integer linear programming
      - project: "h5py"
        ...
```

## For stack developers: DSL focused on overrides

Manage the combinatorial explosion without creating packages for `hdf5_intel_mpich`, `hdf5_gcc_openmpi`, ...:

```
rules:
  ...
  CFLAGS: ["-g", "-O$optlevel"]
  when recipe == "configure-make-install":
    optlevel: 2
  when project == "hdf5":
    recipe: "configure-make-install"
    when version == 1.5.2:
      optlevel: 0
    build_deps:
      - project: "zlib"
        version: 1.2.5 to 1.2.7
  ...
```

## Temporary internal representation in Hashdist

```
dict(
 package='hdf5',
 version='1.8.10',
 recipe='configure-make-install',
 downloads=['http://www.hdfgroup.org/ftp/HDF5/current/'
            'src/hdf5-1.8.10.tar.bz2'],
 sources=['tar.bz2:7jxgwn5xs5xnvsdaomvypridodr35or2'],
 configure=['--prefix=$ARTIFACT', '--with-pic'],
 CFLAGS=['-O2'],
 jail='warn',
 build_deps=[zlib, unix, gcc]
)
```

## For Hashdist developers

Feed it through a Python pipeline:

```
@pipeline.add_recipe('configure-make-install')
def configure_make_install_recipe(ctx, cfg, build):
    build['build']['script'].extend([
        ["LDFLAGS=$(hdist", "build-ldflags", ")"],
        ["CFLAGS=$(hdist", "build-cflags", ")"],
        ["CFLAGS+= " + " ".join(cfg.CFLAGS)],
        ['./configure'] + cfg.configure,
        ['make'],
        ['make', 'install']
        ])
```

## Generated, read by Hashdist developers while debugging

```
{ "import" : [{ "id" : "gcc/apyicmxgafb564zz7rwhwvon7padvxdx"},
               { "id" : "virtual:unix"},
               { "id" : "zlib/wbg27phinbgwjg4nasb4xzf3ypo72otn"}],
   "sources" : [{ "key" : "tar.bz2:7jxgwn5xs5xnvsdaomvypridodr35or2"]},
   "script" : [
        ["LDFLAGS=$(hdist", "build-ldflags", ")"],
        ["CFLAGS=$(hdist", "build-cflags", ")"],
        ["CFLAGS+= -O2"],
        ["./configure", "--prefix=${ARTIFACT}"]
        ["make"],
        ["make", "install"]]
}
```