Hashdist – Yet Another Desperate Attempt at Fixing Scientific Software Distribution

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Ondřej Čertík (U. of Texas, TACC)
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ITA, February 27, 2013

`http://github.com/hashdist`

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  - a) git and GitHub, b) Google and Twitter et al.

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    - What if you want inverse-Gamma RNG?
  - As soon as you want to push boundaries there's a lot of dirty work ahead

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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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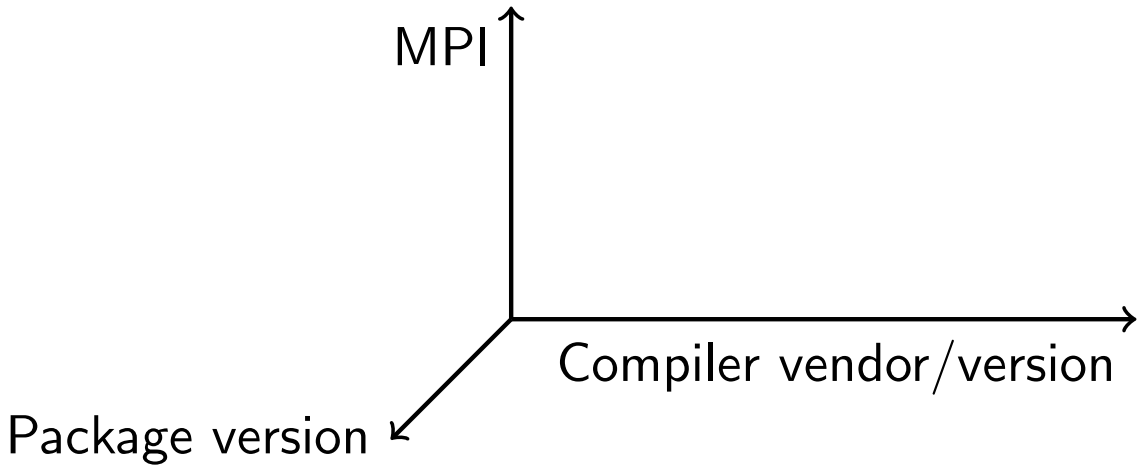

$\times$ LAPACK $\times$ FFT library $\times$ IDL/Python version...

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  - The users need newer/their own libraries

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- The details are different for everybody

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- Perhaps you want 60% curated, 20% bleeding edge or manually tweaked, 20% your own code...

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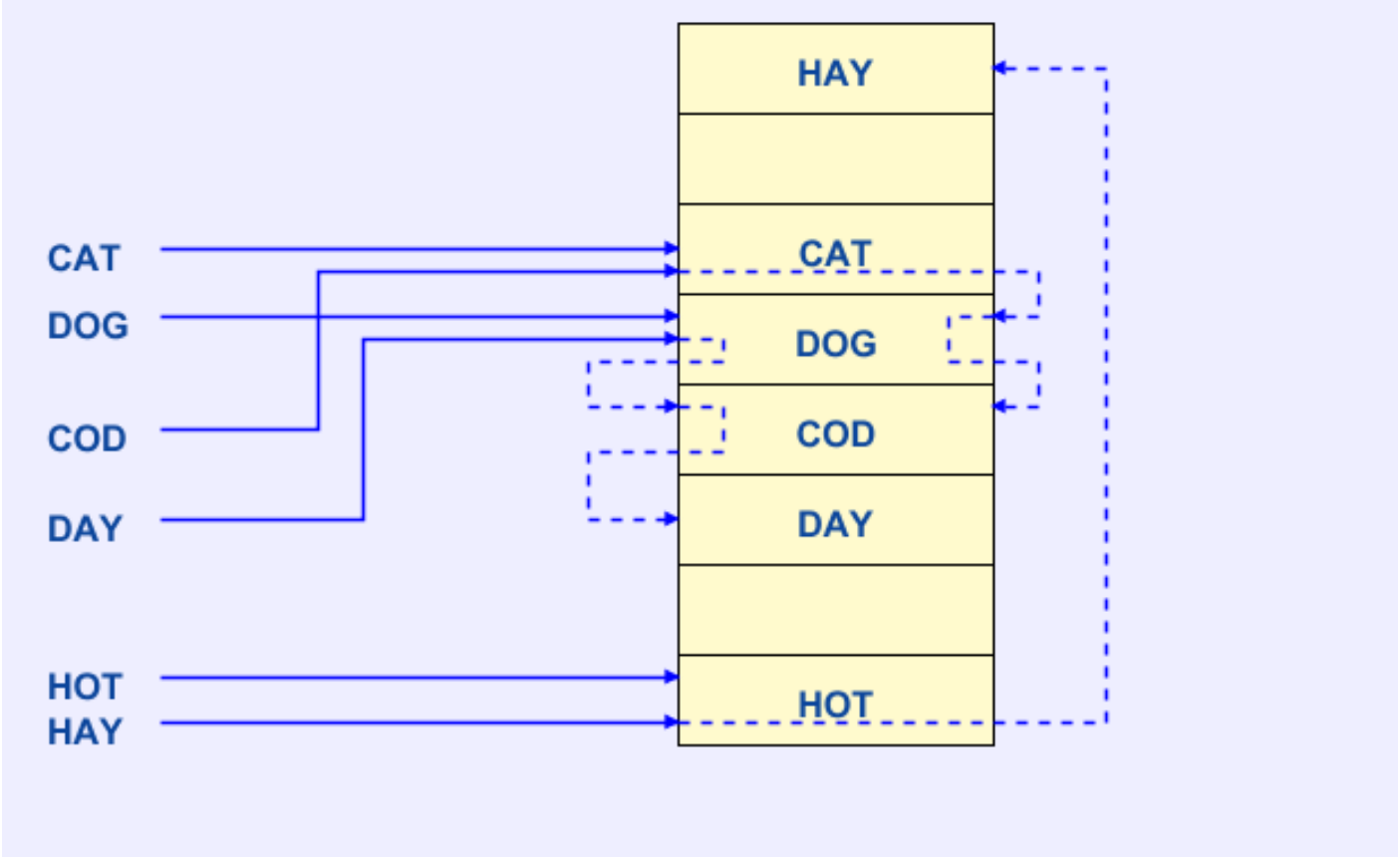
- Need to have new ideas

Theory

Hash function

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

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



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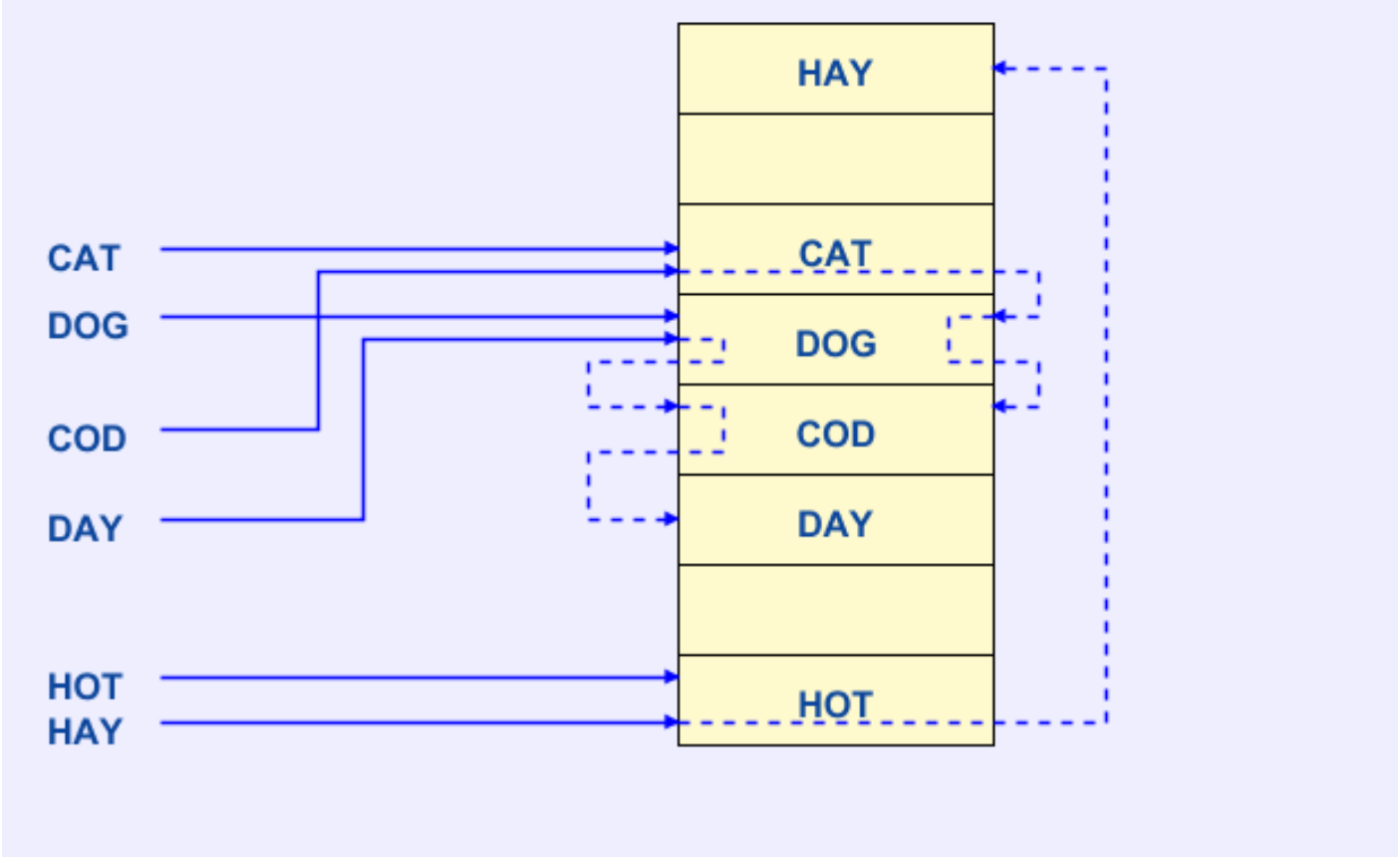

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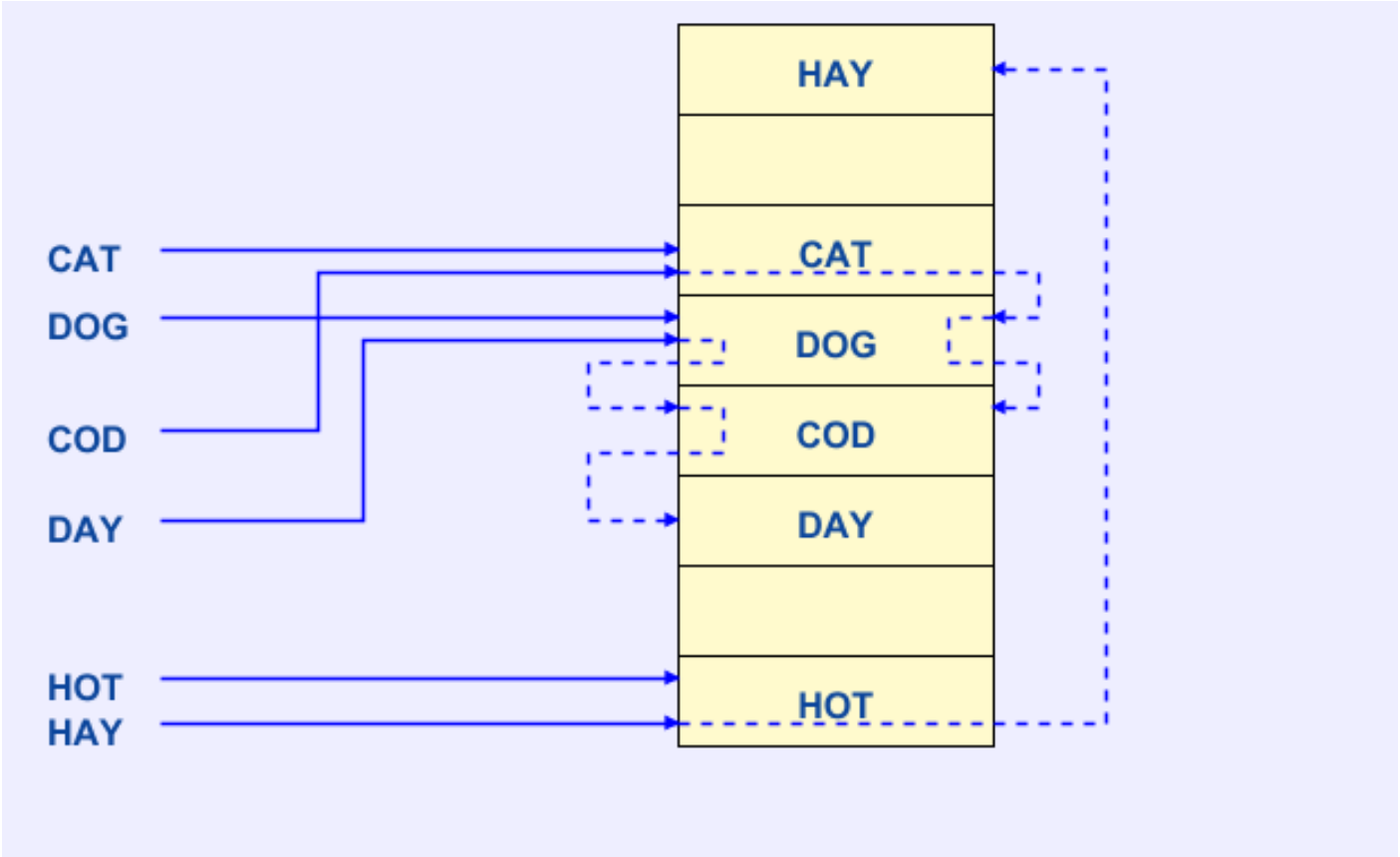

If you know contents up front: Create *perfect* h

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

Image: Hopgood (1968), Computer Bulletin

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$= \texttt{da4b9237bacccdf19c0760cab7aec4a8359010b0}$ 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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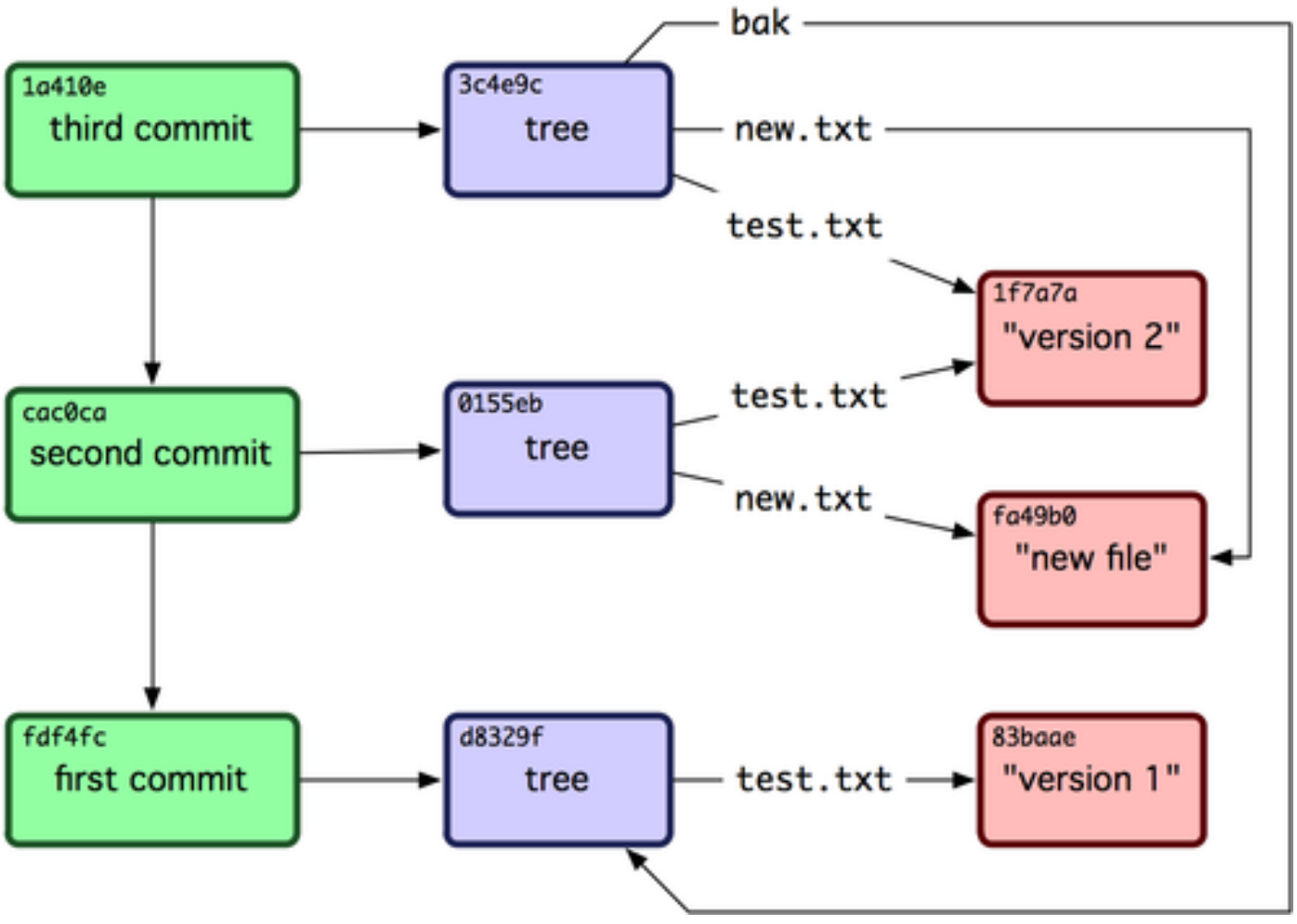

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- Random ID's would work...
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- ...but a hash simultaneously verifies the content!

cython / cython

Pull Request | Unwatch | Unstar 310 | Fork 113

Code | Network | Pull Requests 14 | Wiki | Graphs | Settings

Graph | Members

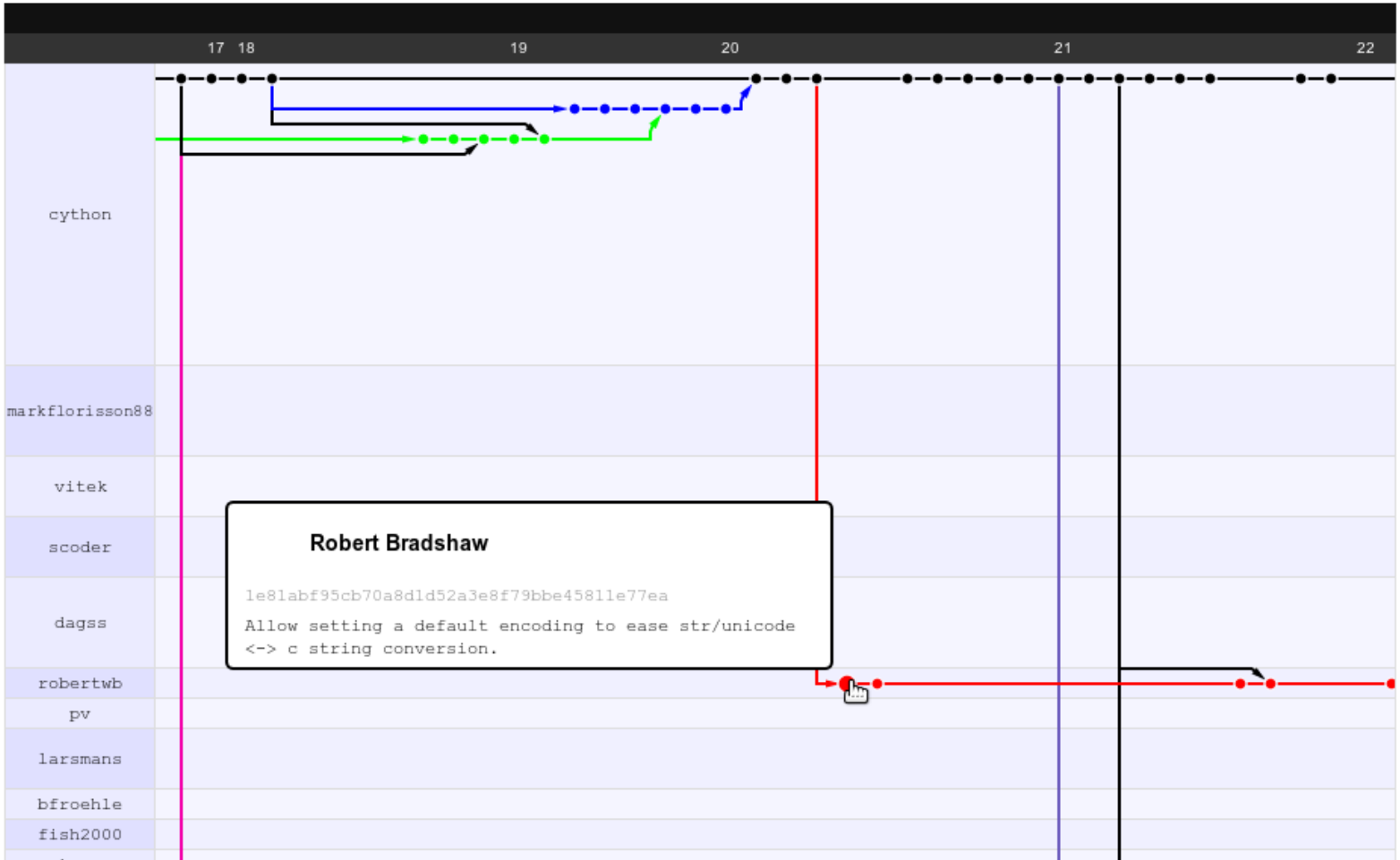
The cython network graph

Keyboard shortcuts available

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

Show Help

Last updated: 12 minutes ago



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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/i7ni/lib/libhdf5.so`
  `~/.hit/opt/hdf5/qgpd/lib/libhdf5.so`

  (really `hdf5/efn3i7ni7lbtik4frlb5wcnqgpdmi3ql`)

Step 1: Hash the build

Internal protocol!

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{
   "name": "hdf5",
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               { "id" : "unix/v-1"},
               { "id" : "zlib/wbg27phinbgwjg4nasb4xzf3ypo72otn"}],
   "sources" : [{ "key" : "tar.bz2:7jxgwn5xs5xnvsdaomvypridodr35or2"}],
   "cmd": ["sh", "$in0"],
   "inputs": [
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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
```

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Unlike “module load“ we don’t need LD_LIBRARY_PATH:

```
$ ldd opt/hdf5/avnj/lib/libhdf5.so
  linux-vdso.so.1 =>  (0x00007fff54b7a000)
  libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0
  libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6
  libz.so.1 => $ORIGIN/../../../zlib/fh7n/libz.so.1
  libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6
  /lib64/ld-linux-x86-64.so.2
```

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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Consequences of hash-based installation

1. More dimensions! Even

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2. For free: Atomic upgrades

   ```
   $ hit upgrade
   # ...then power shuts down, but you're good
   ```

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Sophisticated features with simple implementation

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

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- Up next: Need to provide one (out of many) UI

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

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- 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"]]
}
```