A primer on Nix

and its relevance for safety-critical software systems

Nix As a Package Manager

Nix as Database

Nix as a Configuration Language

Nix as a Linux Distribution

What is Nix? - Components

- Nix CLI
  - For building, installing, and managing packages.
- Nix Store
  - Stores each package in isolation
- Nix Language
  - A purely functional declarative language
- Nixpkgs
  - Over 100,000 packages.
- NixOS
  - Linux distribution built on top of Nix; taking declarativity to the next level

Core concepts: Nix Store - a Database of packages

```
dr-xr-xr-x  - root  1 jan  1970 0a0rfnlqi7287a8319isbqiaqk4y9j0v-source
dr-xr-xr-x  - root  1 jan  1970 0a6c52f5kdvkdggkz0d97yiaa05r1lbz-bat-0.24.0-fish-completions
.r--r--r--  3,5k root  1 jan  1970 0a7drakv7wss56dbg1za593g1ia9ymdd-source.drv
.r--r--r--  2,9k root  1 jan  1970 0a92vy7ncihx1kcw0cncdj8m653yxlis-Babel-2.14.0.tar.gz.drv
.r--r--r--  4,7k root  1 jan  1970 0a2444q1gpvyy8xwnx88w0b7x72pxy3r-perl-5.38.2.drv
dr-xr-xr-x  - root  1 jan  1970 0aavdx9m5ms1cj5pb1dx0brbrbigy8ij-source
.r--r--r--   529 root  1 jan  1970 0abw3lf38k2dj441iwr0lfz2c4ljc8jj-usermod.pam
.r--r--r--   913 root  1 jan  1970 0af36pnpmn76j26vq83p7bfb6ks0kc9f-sshd.conf-final
dr-xr-xr-x  - root  1 jan  1970 0afc5w03x63bwas2xfl8vlmvhciky1h8-expand-response-params
.r--r--r--  3,8k root  1 jan  1970 0aghw59j6mp12ybdc49rlwc2iqnmxlbg-libclc-17.0.6.drv
```

Core concepts: Nix Store - a Database of packages

```
❯ tree /nix/store/g1n2vryg06amvcc1avb2mcq36faly0mh-hello-2.12.1
/nix/store/g1n2vryg06amvcc1avb2mcq36faly0mh-hello-2.12.1
├── bin
│   └── hello
└── share
    ├── info
    │   └── hello.info
    ├── locale
    │   ├── ast
    │   │   └── LC_MESSAGES
    │   │       └── hello.md
. . .
```

Core concepts: Expressions

```
stdenv.mkDerivation {
 name = "hello";
 src = ./src;
 buildInputs = [ libyaml ];
 nativeBuildInputs = [ pkg-config ];

 configurePhase = ''
   declare -xp
 '';

 buildPhase = ''
   $CC "$src/hello.c" -o ./hello
 '';

 installPhase = ''
   mkdir -p "$out/bin"
   cp ./hello "$out/bin/"
 '';
}
```

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Core concepts: Derivations


```
{
  "derivation": {
    "name": "hello-19700101",
    "builder": "/nix/store/dzrvibwj2vjwqmc34wk3x1ffsjpp4av7-bash-4.4-p23/bin/bash",
    "env": {
      "buildInputs": "/nix/store/5r6lgv5il4068nzwinb6nwnx9wgirfxs-libyaml-0.2.5",
      "nativeBuildInputs": "/nix/store/rjxjv5rdh4158kzaxks93i0lkdddihld-pkg-config-wrapper-0.29.2",
      "src": "/nix/store/p57wrsd3904i1kqmd3pxhs6krvi2i4hp-j3j3gwg3kavfjbi2bx7p03z57w2zahyz-source",
      "stdenv": "/nix/store/14cl3y7lg30gw97gphfd7hg8x0cq2czk-stdenv-linux",
    },
    "inputSrcs": [
      "/nix/store/p57wrsd3904i1kqmd3pxhs6krvi2i4hp-j3j3gwg3kavfjbi2bx7p03z57w2zahyz-source"
    ],
    "outputs": {
      "out": {
        "path": "/nix/store/rgkvza100f8wd0alqkrjz85b6ahnjycv-hello-19700101"
      }
    }
  }
}*

* Abbreviated for convenience
```

How Nix Solves the Challenges from Traditional Package Management

What is Nix? - Key features

- Declarative
  - Definition: Describe what the system or package should look like, not how to build it.
  - Benefit: Simplifies configuration management by defining the desired state, making it easier to manage complex systems consistently.
- Reproducible
  - Definition: Ensures that builds is performed in the exact same environment.
  - Benefit: Guarantees that software behaves the same way in development, testing, and production, eliminating "it works on my machine" issues.
- Reliable
  - Definition: Each build is isolated and has no side-effects on the system, with strong guarantees about dependencies.
  - Benefit: Increases system stability and predictability, reducing downtime and maintenance effort.

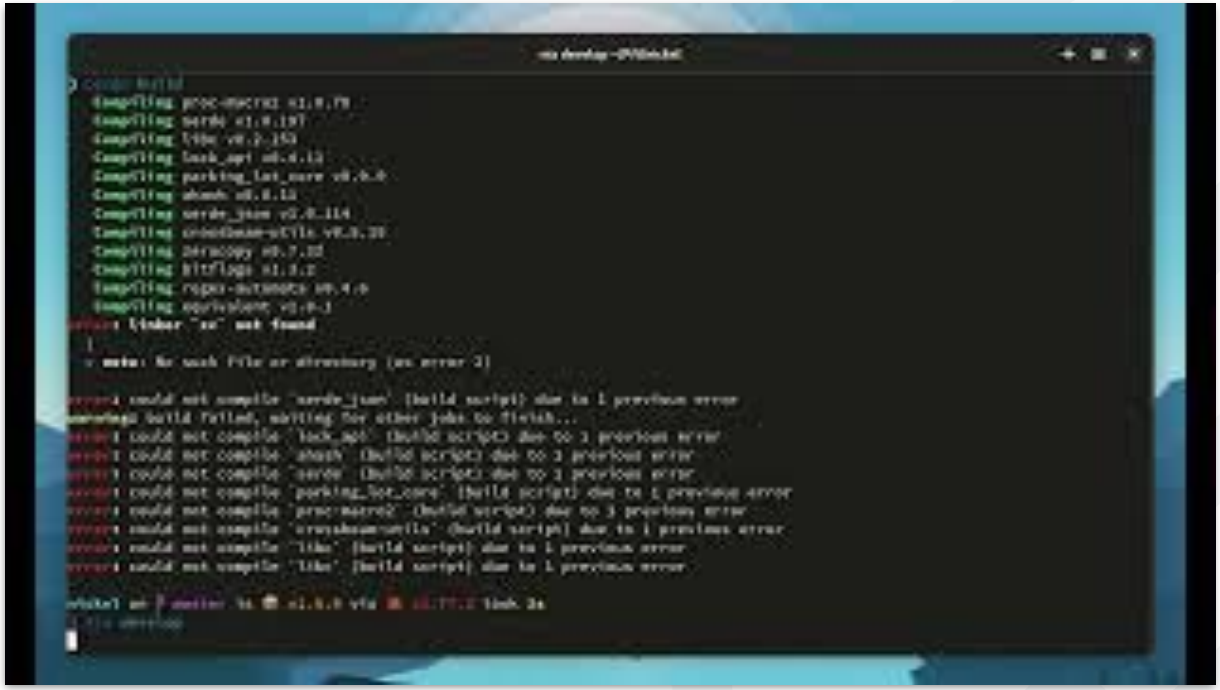
Challenge: Dependency Hell

- Issue: Managing complex dependencies and version conflicts can lead to unstable systems and difficult debugging.
- Solution with Nix: Nix's purely functional package management ensures that all dependencies are explicitly declared and isolated. This prevents version conflicts and allows multiple versions of the same package to coexist without issues.

Challenge: Development Environments

- Issue: Traditional Development Environments rely on non-reproducible setups, causing the infamous “but it works on my machine” arguments.
- Solution: Nix’s reproducibility ensures every developer has the exact same setup to the individual bit.
- Demo time!

Demo: Backup Video



Challenge: Traceability I


```
{
  "derivation": {
    "name": "hello-19700101",
    "builder": "/nix/store/dzrvibwj2vjwqmc34wk3x1ffsjpp4av7-bash-4.4-p23/bin/bash",
    "env": {
      "buildInputs": "/nix/store/5r6lgv5il4068nzwinb6nwnx9wgirfxs-libyaml-0.2.5",
      "nativeBuildInputs": "/nix/store/5f6aw7kg4lfb3rswcfhml94fr8fd4495-hook /nix/store/rjxjv5rdh4158kzaxks93i0lkdddihld-pkg-config-wrapper-0.29.2",
      "src": "/nix/store/p57wrsd3904i1kqmd3pxhs6krvi2i4hp-j3j3gwg3kavfjbi2bx7p03z57w2zahyz-source",
      "stdenv": "/nix/store/14cl3y7lg30gw97gphfd7hg8x0cq2czk-stdenv-linux",
    },
    "inputSrcs": [
      "/nix/store/p57wrsd3904i1kqmd3pxhs6krvi2i4hp-j3j3gwg3kavfjbi2bx7p03z57w2zahyz-source"
    ],
    "outputs": {
      "out": {
        "path": "/nix/store/rgkvza100f8wd0alqkrjz85b6ahnjycv-hello-19700101"
      }
    }
  }
}*
```


* Abbreviated for convenience

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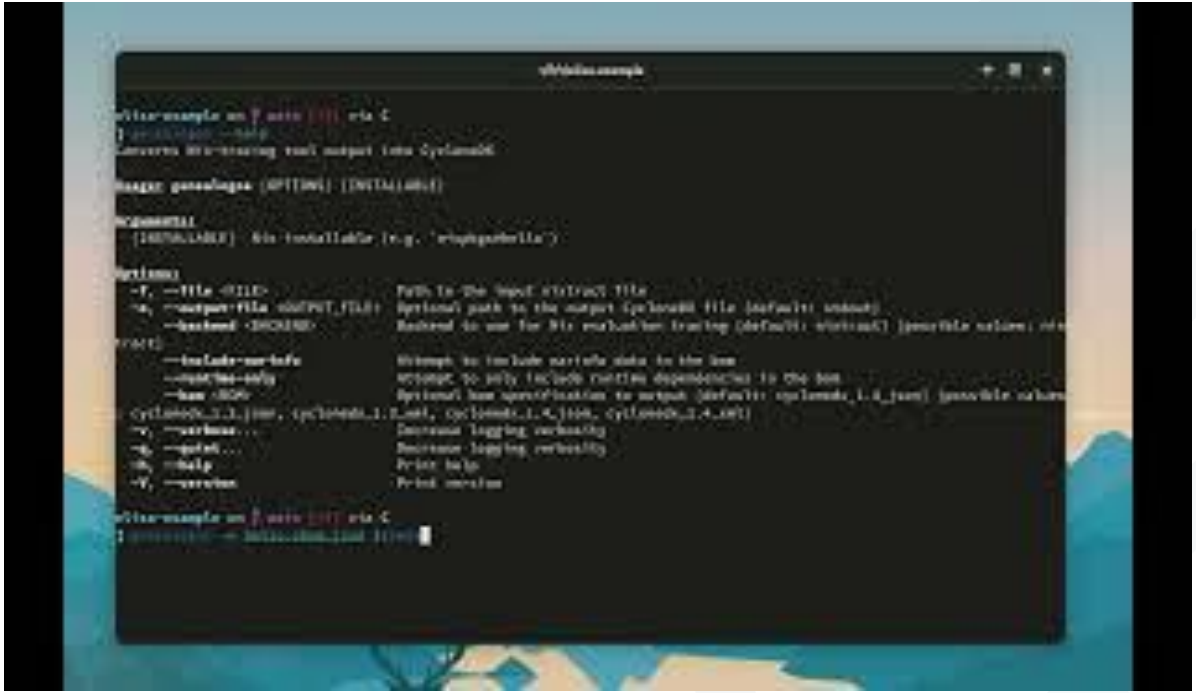
Challenge: Traceability II - Demo



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