Nix: Sandbox and Reproducible Builds

Daniel Hinojosa

About Me

- Developer, Trainer, Coach
- evolutionnext.com
- Java, Scala, Ops, ML, MLOps, Kafka, Event Driven Architecture, Data, IntelliJ
- Available for Consulting, Training and Coaching

In this Presentation

- What is Nix?
- Installing
- Creating Scripts
- Navigating `nixpkgs`
- Pinning

- Nix Language
- Creating Derivations
- Nix Store
- Docker
- Nix OS

Slides and Material: https://github.com/dhinojosa/nix-sandbox-reproducible-builds

What is Nix?

Docker

- Lightweight containerization platform
- Packages applications with all dependencies
- Runs isolated environments using OS-level virtualization
- Uses layered images built from Dockerfiles
- Widely used for reproducible builds and deployments

```
FROM openjdk:21

WORKDIR /app

CMD javac HelloWorld.java && java
HelloWorld
```

DevContainers

- A reproducible development environment defined by code (devcontainer.json)
- Uses Docker (or Podman) to build isolated, consistent dev setups
- Integrated into editors like VS Code and GitHub Codespaces
- Automatically installs tools, extensions, and dependencies
- Great for onboarding, CI consistency, and polyglot development

```
{
  "name": "Java Dev Container",
  "image": "mcr.microsoft.com/
devcontainers/java:21",
  "features": {
    "ghcr.io/devcontainers/features/
docker-in-docker:2": {}
  },
  "customizations": {
    "vscode": {
      "extensions": [
        "vscjava.vscode-java-pack",
        "esbenp.prettier-vscode"
      ]
    }
  },
  "mounts": ["source=java-src,target=/
workspace,type=volume"]
}
```

Docker and DevContainers

Docker

- Large image sizes can slow down builds and pulls
- Imperative builds (`Dockerfiles`) are harder to reason about
- Hidden dependency drift if base images change
- Not fully reproducible over time (mutable layers, tags like `latest`)

DevContainers

- Relies on Docker — inherits its limitations
- Can be slow to start (especially with cold volumes or Codespaces)
- Limited outside of VS Code / Codespaces ecosystem
- Less transparent than declarative systems

What is Nix?

- Nix is a powerful package manager and build system, known for its unique approach to package and configuration management.
- It’s primarily used in Unix-like systems and has several distinctive features:
  - **Functional** Package Management
  - Reliable and Reproducible
  - Isolated Environments
  - Rollbacks and Atomic Upgrades
  - Declarative Configuration
  - Multi-user Profiles

Diff between Nix and Docker?

Differences between Nix and Docker

Feature	Nix	Docker
Primary Goal	Reproducibility of builds and environments	Containerized application deployment
Technology	Functional package manager	Containerization platform
Isolation	None (processes share the host OS)	OS-level process and resource isolation
Dependencies	Declarative package management	Bundled with application in containers
Portability	Cross-platform without containers	Containers run anywhere Docker is supported
Resource Usage	Lightweight, host-level	More resource-intensive (container overhead)
Learning Curve	Steep	Moderate
Use Cases	Package management, CI/CD, reproducibility	App isolation, microservices, cloud deployments

Diff between Nix and DevContainers?

Difference between Nix and DevContainers

Feature	Nix	Dev Containers
Primary Goal	Reproducibility, system-level control	Containerized development environments
Tooling	Nix package manager	Docker, VS Code
Configuration	Declarative Nix language	devcontainer.json, Dockerfiles
Isolation	Process-level isolation	Container-based isolation
Learning Curve	Steep	Moderate
Platform Dependency	None (cross-platform)	Docker + VS Code
Use Case	Package management, CI/CD, local environments	Development-only containerized environments

Nix Derivations

What is a Nix Derivation?

- An Immutable Build Recipe.
- It takes other packages as inputs, you decide what to do with the inputs, and you build another package.
- You are deriving another package based on other packages.
- **This is analogous to how docker images are derived from a base image.**

Nix Scope

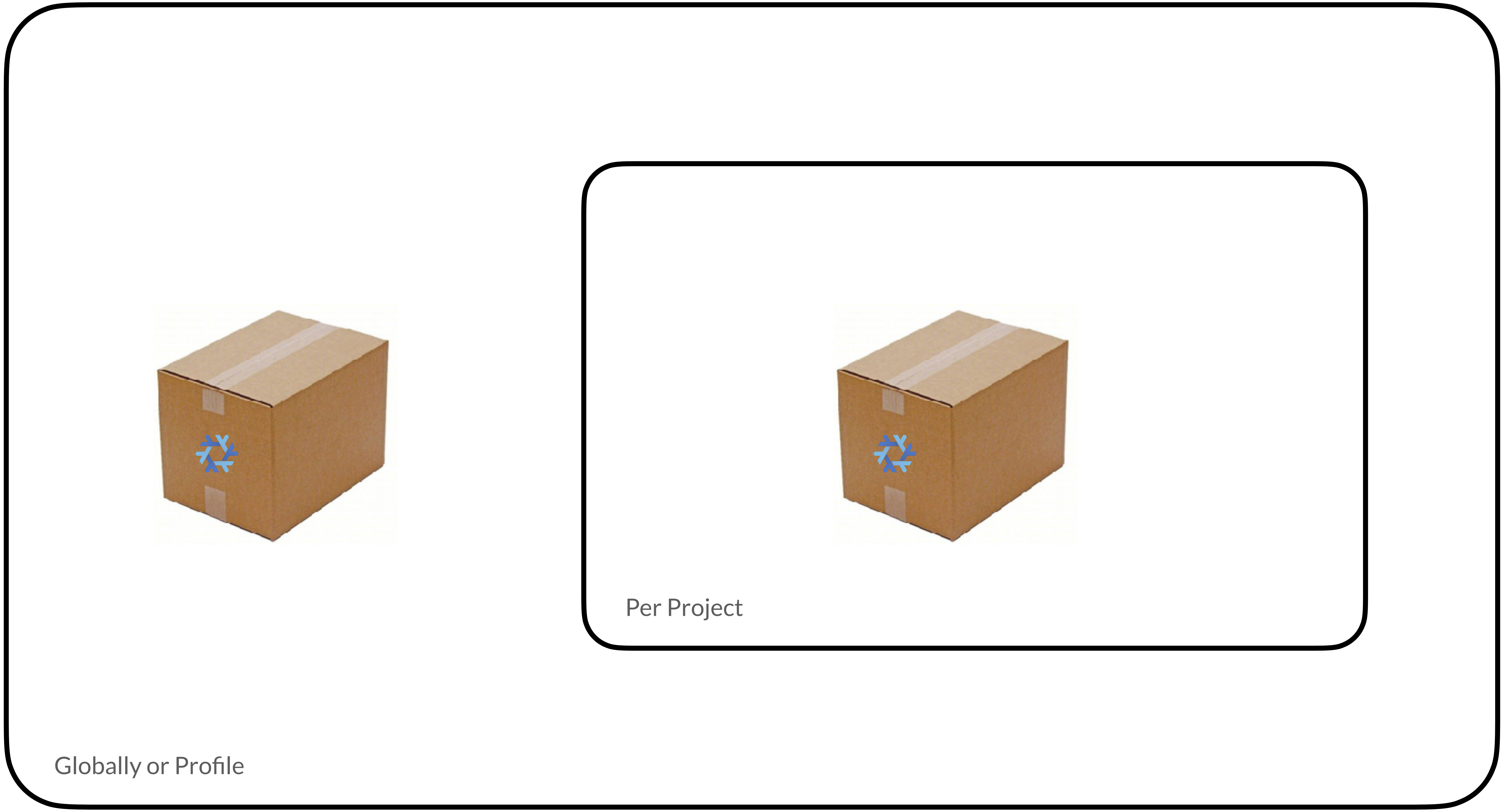
Using Nix

Local to a Project

- Define a shell.nix or flake.nix in your project
- Reproducible dev environments, isolated per project
- Committed to your project and version controls

System-wide

- Install software globally on your machine
- One can establish a profile where one can install certain software packages per profile
- Profiles can be rolled back

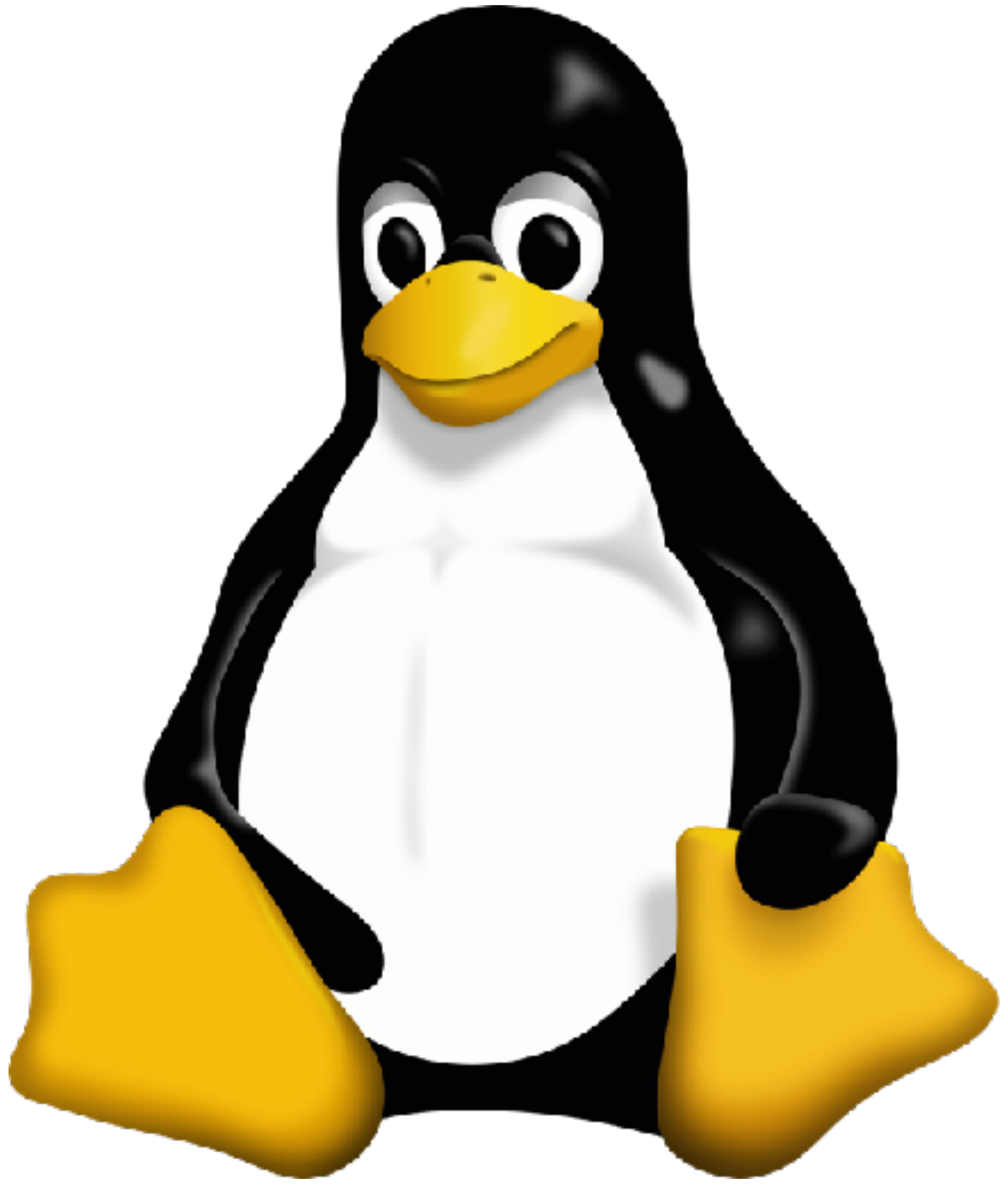


Per Project

Globally or Profile

Installing

Where can it be installed?



Using WSL2

Standard Installation

- The following will run the installer interactively and with explanation
- Performs the default "type" of install for your platform:
  - Single-user on Linux
  - Multi-user on macOS

```
$ curl -L https://nixos.org/nix/install | sh
```

MacOS installs too complex to qualify as single-user, so this type is no longer supported on macOS.

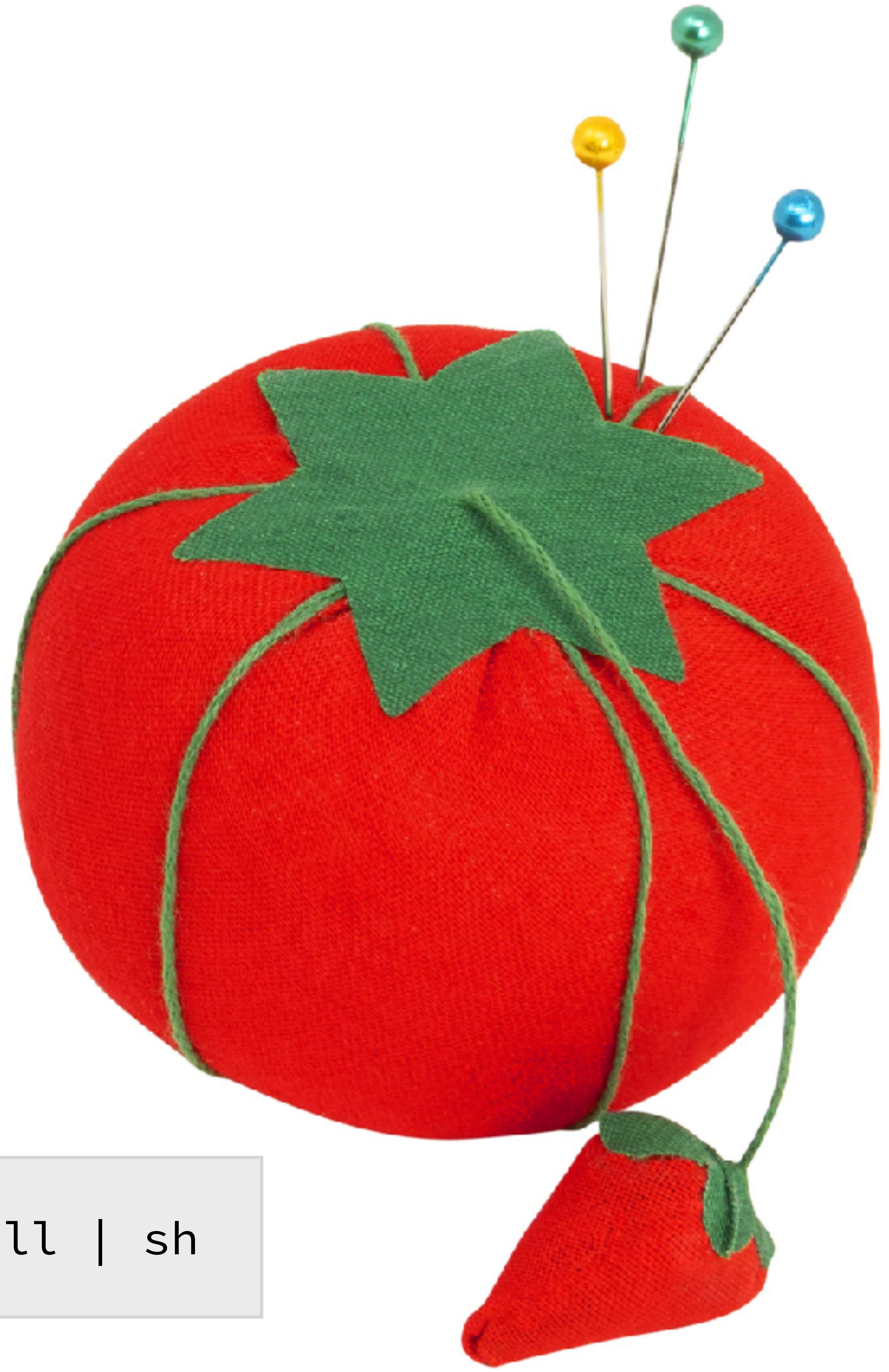
Linux Installation

```
$ curl -L https://nixos.org/nix/install | sh -s -- --daemon
```

Pinned Nix Installations

- Version-specific installation URLs for all Nix versions since 1.11.16 can be found at http://releases.nixos.org

- The corresponding SHA-256 hash can be found in the directory for the given version. Where `<version>` is the pinned version you would like.



```
$ curl -L https://releases.nixos.org/nix/nix-<version>/install | sh
```

Installing from a Tarball

- You can also download a binary tarball that contains Nix and all its dependencies.
- This is what the installation script at https://nixos.org/nix/install does automatically
- Unpack it somewhere (e.g. in /tmp), and then run the script named install inside the binary tarball

```
$ cd /tmp
$ tar xfj nix-1.8-x86_64-darwin.tar.bz2
$ cd nix-1.8-x86_64-darwin
$ ./install
```

Determining which Nix you have

```
$ nix --version
```

Which will return something similar to the following

```
nix (Nix) 2.18.1
```

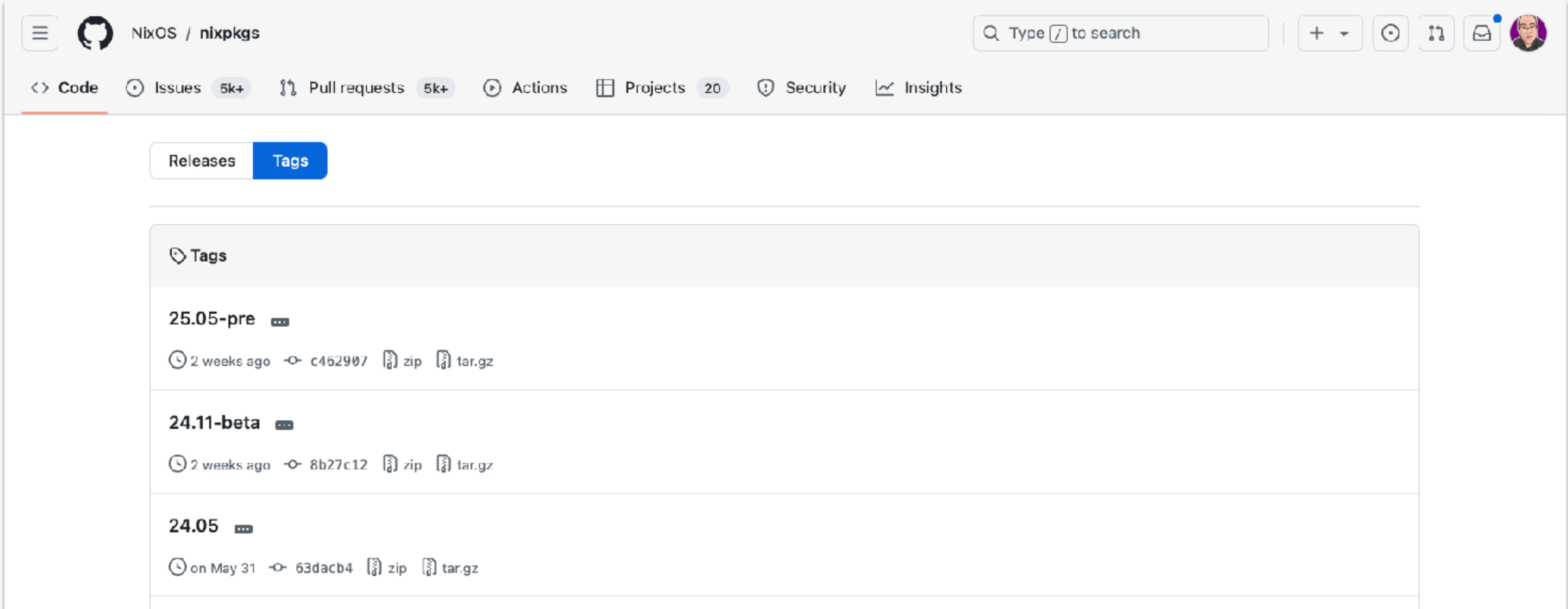
Nixpkgs

What are `nixpkgs`?

- Comprehensive list of packages for the Nix Package manager
- Each package has an associated specific hash
- Ideal for users and developers who need a consistent and reproducible environment across various platforms,

Where are these `nixpkgs`?

- Nix Packages are all a repository, located at https://github.com/NixOS/nixpkgs
- Each tagged version is located at https://github.com/NixOS/nixpkgs/tags



Tags

25.05-pre

2 weeks ago c462907 zip tar.gz

24.11-beta

2 weeks ago 8b27c12 zip tar.gz

24.05

on May 31 63dacb4 zip tar.gz

Demo: NixPkgs

- Let's look at nixpkgs on online and by downloading the version

Using the Shell

```
nix-env -u '*'
```

Trying some commands

```
$ cowsay no can do
The program ‘cowsay’ is currently not installed.

$ echo no chance | lolcat
The program ‘lolcat’ is currently not installed.
```

Trying some commands

- Comprehensive list of packages for the Nix Package manager
- Each package has an associated specific hash
- Ideal for users and developers who need a consistent and reproducible environment across various platforms,

```
$ nix-shell -p cowsay lolcat
```

Demo: Trying some commands

- Let’s try some of the nix commands

The Nix Store

What is Nix Store?

- The immutable storage location for all Nix-managed packages
- Stored in your system as `/nix/store/<hash>-<name>`
- The hash is cryptographic hash (usually SHA-256) that uniquely identifies:
  - All inputs to a build
  - The build instructions themselves
- Meant for these derivations to reproducible
- Nix Store can be pruned

Pruning the Nix Store

- `nix-store --gc --print-dead`
- `nix-store --gc`
- Removes unused paths from `/nix/store`
- Keeps only the packages that are:
  - Currently in user profiles
  - Active system configurations
  - Referenced by GC roots (Root are the currently active)

Demo: Nix-Store

- Let’s show what is in the nix-store
  - We will find the commands that we used in the previous lab to find the derivations of it
  - We will find the nixpkgs as well which is also in the nix-store

Using the REPL

nix-repl

Use nix repl to evaluate Nix expressions interactively (by typing them on the command line)

```
$ nix repl
Welcome to Nix 2.13.3. Type :? for help.

nix-repl> 1 + 2
3
```

Using Instantiate

`nix-instantiate`

- Use nix-instantiate `--eval` to evaluate the expression in a Nix file.
- `--eval` is required to evaluate the file and do nothing else.
- If `--eval` is not present, it is expecting that the file will return a Derivation (which we will talk about soon)

```
$ echo 1 + 2 > file.nix
$ nix-instantiate --eval file.nix
3
```

nix-instantiate

If no name is specified after `--eval`, Nix will look for the *default.nix* file

```
$ echo 1 + 2 > default.nix
$ nix-instantiate --eval
3
```

The Nix *Functional* Language

Nix Language Contents

- Using the Nix language in practice entails multiple things
  - **Language:** syntax and semantics
  - **Libraries:** `builtins` and `pkgs.lib`
  - **Developer tools:** testing, debugging, linting, formatting, …
  - **Generic build mechanisms:** `stdenv.mkDerivation`, trivial builders, …
  - **Composition and configuration mechanisms:** `override`, `overrideAttrs`, `overlays`, `callPackage`, …
  - **Ecosystem-specific packaging mechanisms:** `buildGoModule`, `buildPythonApplication`, …
  - **NixOS module system:** config, option, …

Basics

Language Basics

Whitespace

- Whitespace is used delimit lexical tokens, where required.
- It is otherwise insignificant:

```
let
 x = 1;
 y = 2;
in x + y
```

- It is the same as...

```
let x=1;y=2;in x+y
```

Comments

```
# Comments can be the full line with a hash

/* Multi line comments
   can be done accordingly
   in Java doc style
*/
```

Strings

```
"Hello, World"
```

Special Strings

- Strings can span multiple lines.
- The special characters `"` and `\` and the character sequence `${` must be escaped by prefixing them with a backslash (`\`).
- Newlines, carriage returns and tabs can be written as `\n`, `\r` and `\t`, respectively.

Indentation Strings

- This kind of string literal intelligently strips indentation from the start of each line.
- To be precise, it strips from each line a number of spaces equal to the minimal indentation of the string as a whole (disregarding the indentation of empty lines).
- For instance, the first and second line are indented two spaces, while the third line is indented four spaces.

```
''
  This is the first line.
  This is the second line.
    This is the third line.
''
```

- Thus, two spaces are stripped from each line, so the resulting string is:

```
"This is the first line.\nThis is the second line.\n  This is the third line.\n
```

Booleans

```
true
false
```

Nulls

```
null
```

String Interpolation

- String interpolation can be done with `${}`

```
let
  name = "Nix";
in
"hello ${name}"
```

- This will return with the following:

```
"hello Nix"
```

Use Only Strings in Interpolation

- Only character strings or values that can be represented as a character string are allowed

```
let
  x = 1;
in
"${x} + ${x} = ${x + x}"
```

- This will return with the following error:

```
error: cannot coerce an integer to a string
       at «string»:4:2:

            3| in
            4| "${x} + ${x} = ${x + x}"
             |  ^
            5|
```

When there are no braces, it’s a variable

- `$out` is a special variable that will store in `/nix/store`
- `${out}` is an interpolation of what is in `let`
- `out` in let is just a variable declaration

```
let
  out = "Nix";
in
"echo ${out} > $out"
```

Lists

- Lists are formed enclosing *whitespace-separated list of values* between *square brackets*

- The following includes a number, a path, a string, a function with an attribute. Functions have to be surrounded by parenthesis ()

```
[ 123 ./foo.nix "abc" (f { x = y; }) ]
```

Creating a List and Mapping

```
let
  # Generate a list [1, 2, 3, 4, 5]
  numbers = [ 1 2 3 4 5 ];

  # Map each element (e.g., multiply by 2)
  doubledNumbers = builtins.map (x: x * 2) numbers;
in
  doubledNumbers
```

Attribute Sets

- Name, Value pairs in a set of curly brackets `{}`
- The attribute name must be a valid String or an identifier
- An identifier must start with a letter (`a-z`, `A-Z`) or underscore (`_`), and can otherwise contain letters (`a-z`, `A-Z`), numbers (`0-9`), apostrophes (`'`), or dashes (`-`)

Attribute Set Example

```
{
  x = 123;
  text = "Hello";
  y = f { bla = 456; };
}
```

- Use a `.` to access the value. The following resolves to "Foo"

```
{ a = "Foo"; b = "Bar"; }.a
```

Getting a default value from an attribute

- Provide a default value in an attribute selection using the or keyword.
- In the following both will resolve to "Xyzzy"

```
{ a = "Foo"; b = "Bar"; }.c or "Xyzzy"
{ a = "Foo"; b = "Bar"; }.c.d.e.f.g or "Xyzzy"
```

Attribute Names can be double quoted

- You can use arbitrary double-quoted strings as attribute names
- Both of the following will be evaluated to `123`

```
{ "$!@#?" = 123; }."$!@#?"

let bar = "bar"; in
{ "foo ${bar}" = 123; }."foo ${bar}"
```

Attribute Names support interpolation

- Here interpolation can be used in both the attribute name and the value
- Both of the following will resolve to 123

```
let bar = "foo"; in
{ foo = 123; }.${bar}
```

```
let bar = "foo"; in
{ ${bar} = 123; }.foo
```

`null` prevents attribute name being added to the Set

- When an attribute name inside a set declaration evaluates to `null`, that attribute is simply not added to the set
- Reason is that `null` cannot be coerced to a string
- The following will evaluate to `{}`, an empty attribute set, if `foo` evaluates to `false`.

```
{ ${if foo then "bar" else null} = true; }
```

Recursive Attribute

```
rec {
  one = 1;
  two = one + 1;
  three = two + 1;
}
```

- The previous evaluates to the following:

```
{ one = 1; three = 3; two = 2; }
```

let..in

- Also called `let` binding.
- `let` expressions allow assigning names to values for repeated use

```
let
  a = 1;
in
a + a
```

`with`

- The with expression allows access to attributes without repeatedly referencing their attribute set.

```
let
  a = {
    x = 1;
    y = 2;
    z = 3;
  };
in
with a; [ x y z ]
```

- Where `with a; [ x y z ]` is the same as `[ a.x a.y a.z ]`

`with` out of scope

- In the following, `c=x` would return an error since `x` is not within scope
- The `x` in `b = with a; [ x y z ]` is valid, since `with` puts `a` in scope

```
let
  a = {
    x = 1;
    y = 2;
    z = 3;
  };
in
{
  b = with a; [ x y z ];
  c = x;
}
```

inherit

- It pulls variables already in scope into an attribute set with the same name.

```
let
  x = 1;
  y = 2;
in
{
  inherit x y;
}
```

- Results in, and is equivalent to `x = x; y = y;`

```
{ x = 1; y = 2; }
```

inheriting specific attributes

- It is also possible to inherit names from a specific attribute set with parentheses (`inherit (… ) … )`.

```
let
  a = { x = 1; y = 2; };
in
{
  inherit (a) x y;
}
```

- Results in, and is equivalent to `x = a.x; y = a.y`

```
{ x = 1; y = 2; }
```

`inherit` inside a `let`

- In a let, it will destructure to the values

```
let
  inherit ({ x = 1; y = 2; }) x y;
in [ x y ]
```

- Results in

```
[ 1 2 ]
```

Functions

Common Functions to Use

Functions

Functions are similar to lambdas in many programming languages

Single Argument Function:

```
x: x + 1
```

Multiple Argument Function:

```
x: y: x + y
```

Attribute Sets

Attribute Sets are Key-Value Structures

```
{
  key1 = "value1";
  key2 = 42;
  key3 = [ "list" "of" "values" ];
  nested = {
    subkey1 = "nested value";
  };
}
```

Attribute Set Arguments in Functions

Arguments can also be attributes, here the argument must be an attribute

```
{ a, b }: a + b
```

Arguments can also be attributes, here the argument must be an attribute

```
{ a, b ? 0 }: a + b
```

Repeated Parameter Arguments

Additional Arguments can also be applied

```
{ a, b, ...}: a + b
```

Named Attribute Set

```
args@{ a, b, ... }: a + b + args.c
```

or

```
{ a, b, ... }@args: a + b + args.c
```

Calling a Single Argument Function

```
let
  f = x: x + 1;
in f 1
```

Calling a Single Argument Function as an Attribute

```
let
  f = x: x.a;
in
f { a = 1; }
```

Calling a Single Argument Function by Attribute Name

```
let
  f = x: x.a;
  v = { a = 1; };
in
f v
```

Calling a Function Inline

```
(x: x + 1) 1
```

Non-Evaluated List of Functions

```
let
 f = x: x + 1;
 a = 1;
in [ f a ]
```

Renders:

```
[ <LAMBDA> 1 ]
```

Nix is lazily evaluated

Evaluation of a List of Functions

```
let
 f = x: x + 1;
 a = 1;
in [ (f a) ]
```

Renders:

```
[ 2 ]
```

Multiple Arguments

- Known as "curried" functions
- Functions are nested, therefore can be applied as down payments

```
x: y: x + y
```

- Applying x with 3 will return a function `y: 3 + y`
- When y is applied with, say, 9 we will get 12

Attribute Set Arguments

- Also known as “keyword arguments” or “destructuring” .
- Nix functions can be declared to require an attribute set with specific structure as argument.

```
{a, b}: a + b
```

- Here we can apply this function with an attribute:

```
let
  f = {a, b}: a + b;
in
f { a = 1; b = 2; }
```

Unexpected Arguments in Attribute Set Argument

- The following will return an error, c is not in the argument attribute set

```
let
  f = {a, b}: a + b;
in
f { a = 1; b = 2; c = 3; }
```

- If you really need c it should be used and possibly be declared in the incoming attribute set

Default Values

- Arguments can be brought in with defaults
- This is denoted by separating the attribute name and its default value with a question (?).
- Attributes in the argument are not required if they have a default value.

```
let
  f = {a, b ? 0}: a + b;
in
f { a = 1; }
```

Default Values with an Empty Set

If all the attribute set has a default value, then you can just send an empty attribute set

```
let
  f = {a ? 0, b ? 0}: a + b;
in
f { }
```

Additional Attributes

- Additional attributes are allowed with an ellipsis (...)
- This is referred to in other languages as varargs, repeated parameters, etc.

```
let
  f = {a, b, ...}: a + b;
in
f { a = 1; b = 2; c = 3; }
```

Named Attribute Set Pattern

- Also known as “`@` pattern”, “`@` syntax”, or “‘at syntax”.

- An attribute set argument can be given a name to be accessible as a whole.

- This is denoted by prepending or appending the name to the attribute set argument, separated by the at sign (`@`).

```
{a, b, ...}@args: a + b + args.c
```

```
args@{a, b, ...}: a + b + args.c
```

- How it is applied...

```
let
  f = {a, b, ...}@args: a + b + args.c;
in
f { a = 1; b = 2; c = 3; }
```

Additional Attributes

- Also known as “primitive operations” or “primops”.
- Nix comes with many functions that are built into the language.
- They are implemented in C++ as part of the Nix language interpreter.
- Let’s visit the list of functions

Nix Libraries `pkgs.lib`

- The `nixpkgs` repository contains an attribute set called `lib`, which provides a large number of useful functions.
- They are implemented in the Nix language, as opposed to `builtins`, which are part of the language itself.

```
let
  pkgs = import <nixpkgs> {};
in
pkgs.lib.strings.toUpper "lookup paths considered harmful"
```

This is not the idiomatic way to do so, since <nixpkgs> can be any version

Nix Libraries `pkgs.lib` Consistently

- The following uses pinning
- This is now forming a typical file in Nix and how to go about using it.

```
let
  nixpkgs = fetchTarball https://github.com/NixOS/nixpkgs/archive/06..b.tar.gz;
  pkgs = import nixpkgs {};
in
pkgs.lib.strings.toUpper "always pin your sources"
```

Using a variable pkgs

- In the following we see… … a lambda, or function, that accepts `pkgs` as a variable
- It’s not particularly typed, so we will have to assume that it is `<nixpkgs>`

```
{ pkgs, ... }:
pkgs.lib.strings.removePrefix "no " "no true scotsman"
```

Where does pkgs come from?

If you have a file with arguments like pkgs they can come from the command line or another file, like *default.nix*

```
$ nix-instantiate --eval file.nix --arg pkgs 'import <nixpkgs>
{}'
"true scotsman"
```

What if we have `lib` as a variable?

Given the following nix file:

```
{ lib, ... }:
let
  to-be = true;
in
lib.trivial.or to-be (! to-be)
```

We can call the file with:

```
$ nix-instantiate --eval file.nix --arg lib '(import <nixpkgs>
{}).lib'
```

Bringing in multiple arguments

You can explicitly bring in multiple arguments in a nix file to avoid any ambiguity

```
{ pkgs, lib, ... }:
# ... multiple uses of `pkgs`
# ... multiple uses of `lib`
```

How do we introspect?

`builtins.trace` offers a way to show evaluations as you run them

```
let
  a = 10;
  b = 20;
  c = builtins.toString a;
in
  builtins.trace "What we have ${c}" (a + b)
```

Showing types and docs

`:t` in the nix-repl will try to show the result type of the evaluation

```
:t <expr>
```

`:doc` will show the documentation of any `builtin`

```
:doc <expr>
```

Builtins

Items that are built-in to the languages

Built-in Constants and Values

- Nix `builtins` offers many constants and value like
  - `systemtime`
  - `currentSystem`
  - `false, and true`
  - `nixPath`
  - `nixVersion`
  - `storeDir`

Importing

Bringing in from other sources

`import`

- `import` takes a path to a Nix file, reads it to evaluate the contained Nix expression, and returns the resulting value.

- If the path points to a directory, the file default.nix in that directory is used instead.

```
echo 1 + 2 > file.nix
```

```
import ./file.nix
```

`importing` a function

Whenever you see additional tokens after a call to import, the value it returns should be a function, and anything that follows are arguments to that function.

```
$ echo "x: x + 1" > file.nix
```

```
import ./file.nix 1
```

Fetchers

Getting binaries for your derivation

Fetchers

- The Nix language provides built-in impure functions to fetch files over the network during evaluation:
  - `builtins.fetchurl`
  - `builtins.fetchTarball`
  - `builtins.fetchGit`
  - `builtins.fetchClosure`
- These functions evaluate to a file system path in the Nix store

Fetchers

Fetches content from a URL

```
builtins.fetchurl "https://github.com/NixOS/nix/archive/7c..ff.tar.gz"
```

Fetches content from a URL and unpacks the tar

```
builtins.fetchTarball "https://github.com/NixOS/nix/archive/7c..ff.tar.gz"
```

View more fetchers in the NixOS Manual

Paths

How to use paths within Nix

Path

- Paths of course refer to the accessing files from the file system
- Paths need to contain at least one / to be considered a path

Absolute Path System Paths

- The Nix language offers convenience syntax for file system paths.
- Absolute paths always start with a slash (/).

```
/absolute/path
```

Relative File System Paths

- Paths are relative when they contain at least one slash (/) but do not start with one. They evaluate to the path relative to the file containing the expression.
- Assuming we are in `/current/directory`

Resolves to `/current/directory/relative`

```
./relative
```

Resolves to `/current/directory/relative/path`

```
relative/path
```

Paths with a `.`

- Since relative paths must contain a slash (`/`) but must not start with one, and the dot (`.`) denotes no change of directory, the combination `./.` specifies the current directory as a relative path.

- Assuming we are in `/current/directory`, the following resolves to `/current/directory`

```
./.
```

Lookup Paths

- The angle bracket path that represents an actual path

```
<nixpkgs>
```

- Resolves to the location of nixpkgs:

```
/nix/var/nix/profiles/per-user/root/channels/nixpkgs
```

Lookup Paths with Directories

- A path can be added to the nixpkgs

```
<nixpkgs/lib>
```

- Resolves to the location of nixpkgs:

```
/nix/var/nix/profiles/per-user/root/channels/nixpkgs/lib
```

- Doing this is not recommended since they are impure

Paths and Nix-Store

- When a file is used in string interpolation that file is added to the Nix Store as a side effect

```
$ echo 123 > data
```

```
"${./data}"
```

- Results in

```
"/nix/store/h1qj5h5n05b5dl5q4nldrqq8mdg7dhqk-data"
```

- The results here are of the format `/nix/store/<hash>-<name>`

Such interpolated expressions must evaluate to something that can be represented as a character string.
A file system path is such a value, and its character string representation is the corresponding Nix store path

Paths and Interpolation

- Paths can include string interpolation and can themselves be interpolated in other expressions.
- At least one slash (/) must appear before any interpolated expression for the result to be recognized as a path.
- `a.${foo}/b.${bar}` is a division operation.
- `./a.${foo}/b.${bar}` is a path.

Demo: Let's See if we can read a Derivation

- Now that we know the language, can we see what a derivation does?

Creating a Default File

Creating a Default File

- `default.nix` Nix expression file used to define build or environment configurations.
- Acts as the default entry point for many Nix commands.
- Helps standardize and automate package builds or project setups.
- Works with `nix-shell` and `nix-build`.

Basic *default.nix* file

```
{ pkgs ? import <nixpkgs> {} }:

pkgs.mkShell {
  buildInputs = [
    pkgs.neovim
    pkgs.rustc
    pkgs.kubectl
  ];
}
```

You can then run this with nix-shell

```
nix-shell
```

Demo: Creating a Java default.nix

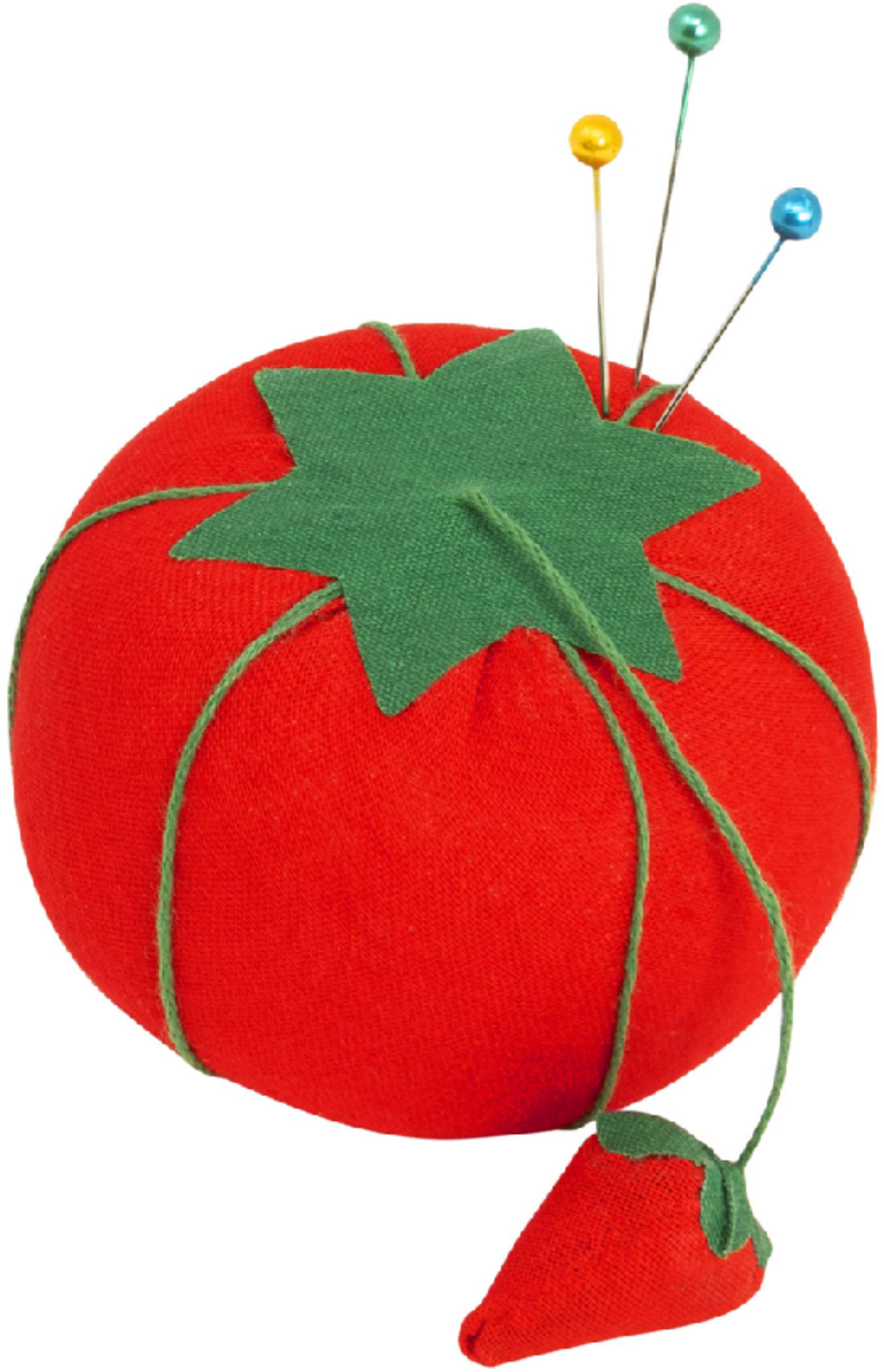
- Let’s create a default.nix file for a Java project:
  - Open JDK
  - Maven
  - neovim
  - kubectl

Pinning

Ensuring Repeatable Packages

Pinning Nix

- Pinning in Nix refers to fixing a specific version of the `nixpkgs` repository or other dependencies to ensure a reproducible and stable environment.
- Ensures that builds produce the same results, even if the nixpkgs repository evolves.
- Locks dependencies to a known good state, avoiding unexpected breakages due to upstream changes.



Pinning Nix

- Pinning package on a tarball

```
pkgs ? import (fetchTarball "https://github.com/NixOS/nixpkgs/
archive/refs/tags/24.05.tar.gz") {}
```

- Pinning package on a git

```
pkgs ? import (fetchGit {
  url = "https://github.com/NixOS/nixpkgs.git";
  rev = "a1b2c3d4e5"; # Specific commit hash
}) {}
```

Demo: Pinning

- Let’s take a look at two forms of pinning.
  - Single Channel Pinning
  - Many Channel Pinning

Nix Derivations

Reminder: What is a Nix Derivation?

- An Immutable Build Recipe.
- It takes other packages as inputs, you decide what to do with the inputs, and you build another package.
- You are deriving another package based on other packages.
- **This is analogous to how docker images are derived from a base image.**

Every package in `nixpkgs` is a derivation

- If you download the repository or view the package repository you will see all the applications that are available for you to use download and use in your *default.nix*
- You will find that in nearly all the nix files that they will either be a flake or standard nix file *that will have* `mkDerivation`
- ***The choice is yours; use derivations for your own project, or use derivations to create your own derivations.***

You have been deriving all along

```
FROM jenkins/jenkins:lts

# Switch to root to install Docker CLI
USER root

# Install Docker CLI
RUN apt-get update && \
    apt-get install -y docker.io && \
    apt-get clean

# Install Jenkins Docker plugin
RUN /usr/local/bin/install-plugins.sh docker

# Change back to Jenkins user
USER jenkins
```

An example of a derivation

```
{ pkgs ? import <nixpkgs> {} }:

pkgs.stdenv.mkDerivation {
  name = "hello-world";
  src = null;

  buildCommand = ''
    echo "Hello, Nix!" > $out
  '';
}
```

Create and use the derivation

- Run nix-build against the default.nix file with the derivation

```
nix-build
```

- View the result

```
cat ./result
```

- View the directory of the result

Demo: Derivation

- Let’s take a look at derivation

Derivation Phases

Callbacks within your Derivation

Controlling

- The formal term is *Controlling Phases* - Package builds are split into phases to make it easier to override specific parts of the build (e.g., unpacking the sources or installing the binaries).

- Each phase can be overridden in its entirety either by setting the environment variable namePhase to a string containing some shell commands to be executed, or by redefining the shell function namePhase.

- When overriding a phase, for example `installPhase`, it is important to start with `runHook, preInstall` and end it with `runHook postInstall`, otherwise `preInstall` and `postInstall` will not be run.

- Even if you don’t use them directly, it is good practice to do so anyway for downstream users who would want to add a postInstall by overriding your derivation.

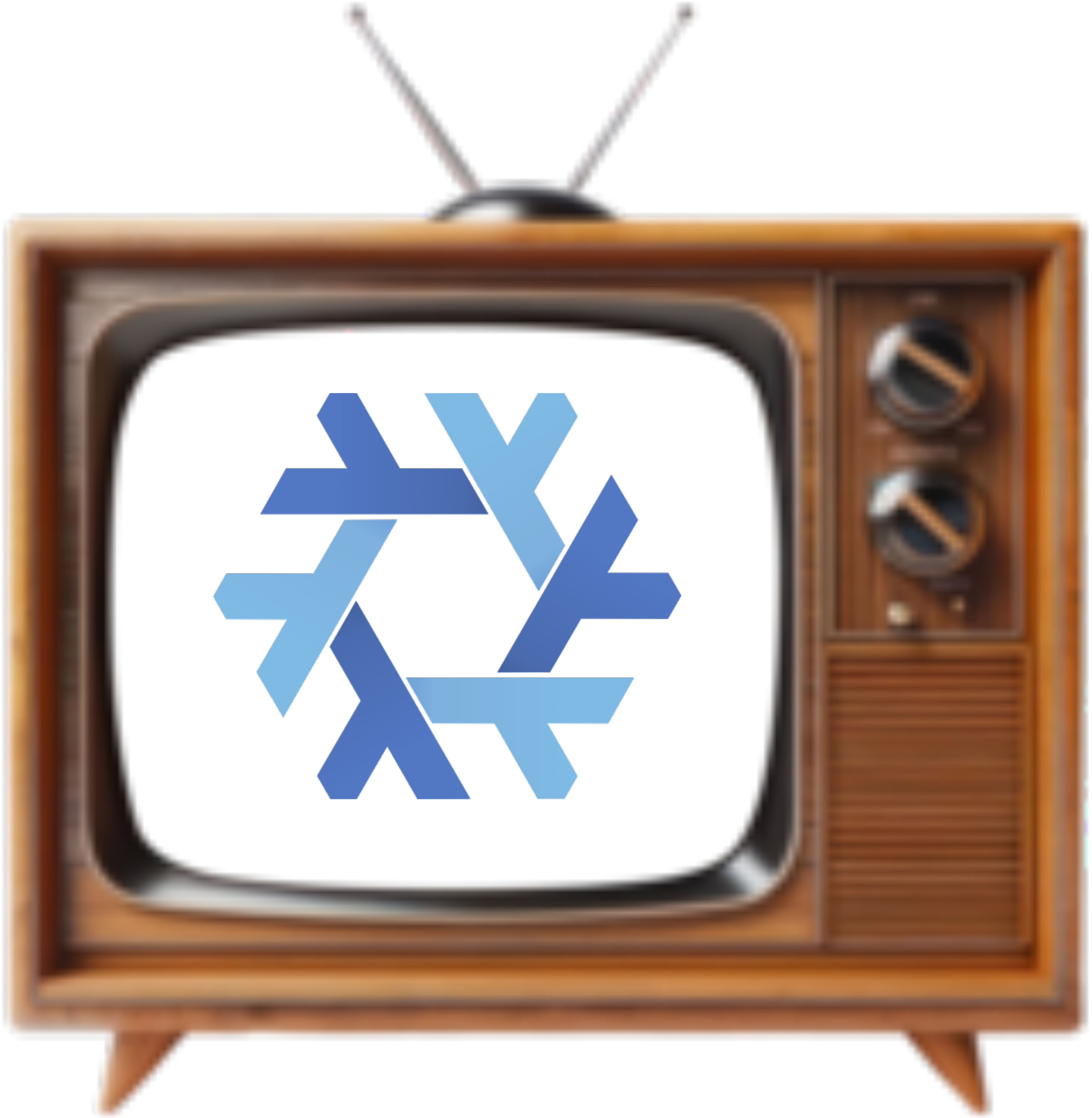
Demo: Derivation Phases

- Let’s take a look at derivation with phases

Nix Channel

What is a Nix Channel?

- A named pointer to a specific revision of the `nixpkgs` repository
- Used by legacy Nix workflows (before flakes)
- Provides packages to nix-env, nix-shell, etc.



Uploading your Derivation

How do upload a derivation?

- Prepare and test your derivation
- Clone `nixpkgs` directory

```
git clone https://github.com/NixOS/nixpkgs.git
cd nixpkgs
```

- Add your derivation to the appropriate directory
- Create a pull request
- Respond to your pull request

Managing Packages

`nix-env`

- You can use it to install, upgrade, and erase packages
- Used to query what packages are installed or are available for installation

Creating Docker Images with Nix

Nix to create Docker images

- Nix can also be used to create consistent Docker images.
- Builds are declarative, ensuring dependencies are explicitly defined.

```
{ pkgs ? import <nixpkgs> {} }:
pkgs.dockerTools.buildImage {
  name = "my-docker-image";
  contents = [ pkgs.hello ];
  config = {
    Cmd = [ "hello" ];
  };
}
```

Demo: Docker Image

- Let’s take a look at how we can create a docker-image using Nix
- Then we can also take a look at a multistage build with Docker

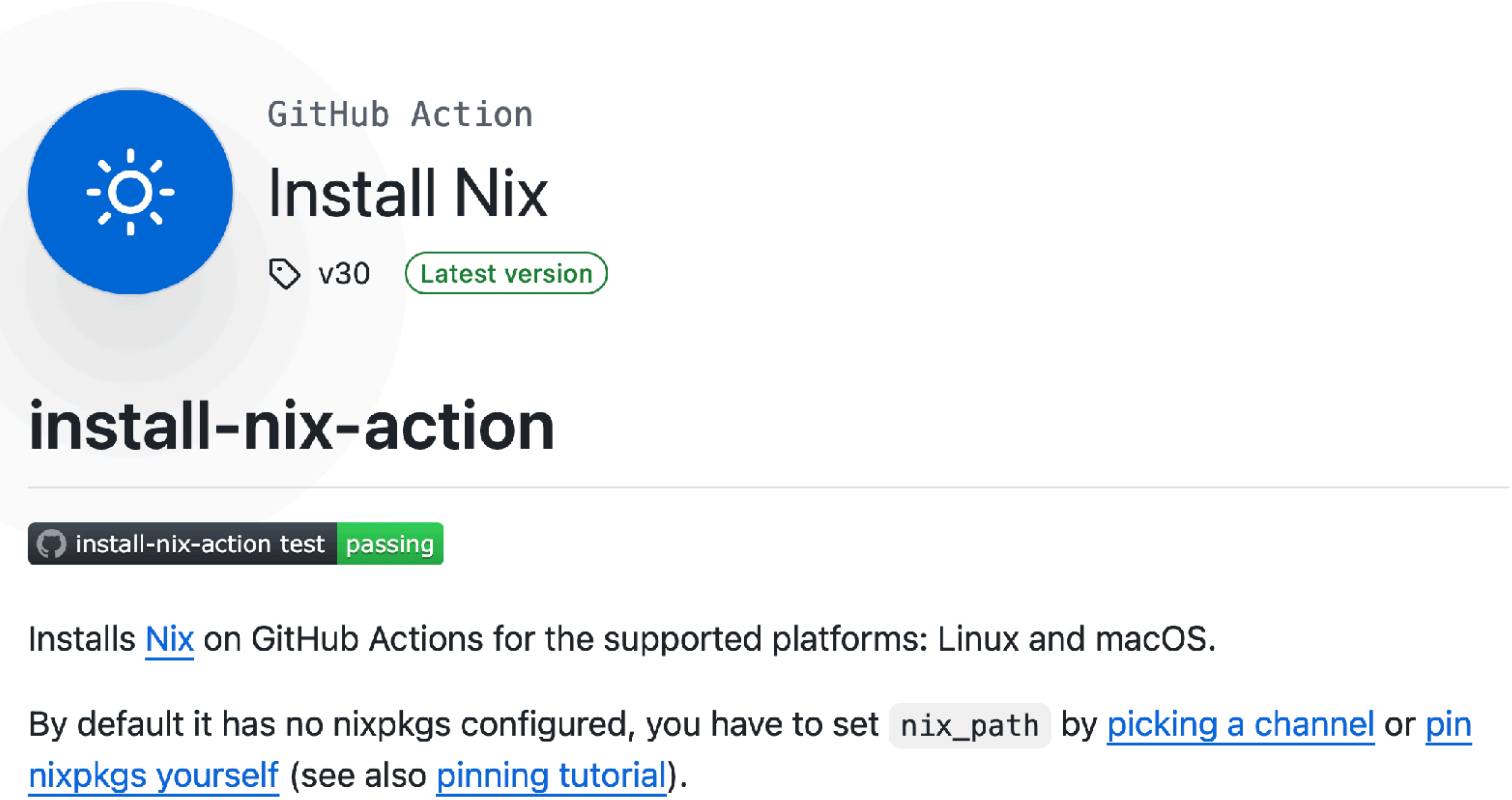
Using CI/CD

Using CI/CD with Nix

- Your remote agents can run anything, each agent can have its own nix store

```
stages {
    stage('Setup') {
      steps {
        sh '''
        . /etc/profile.d/nix.sh
        nix-channel --update
        '''
      }
    }
    stage('Build') {
      steps {
        sh '''
        . /etc/profile.d/nix.sh
        nix-build ./default.nix
        '''
      }
    }
}
```

Github Actions



GitHub Action

Install Nix

v30 Latest version

install-nix-action

install-nix-action test passing

Installs Nix on GitHub Actions for the supported platforms: Linux and macOS.

By default it has no nixpkgs configured, you have to set `nix_path` by picking a channel or pin nixpkgs yourself (see also pinning tutorial).

Nix Flakes

What are Nix Flakes?

- An experimental feature that is aimed to improve the main features of Nix derivations
- Flakes aim to make Nix configurations more reproducible, shareable, and composable. Here are the key aspects of Nix Flakes
- Flakes represent an evolution in the Nix ecosystem, aiming to solve long-standing issues around reproducibility and usability.
- They’re particularly appealing for developers seeking to create reproducible development environments and for Nix users who need to manage complex system configurations.

What’s great about Flakes?

- A flake.nix file offers a uniform schema
- Other flakes can be referenced as dependencies providing Nix language code or other files.
- The values produced by the Nix expressions in flake.nix are structured according to pre-defined use cases.
- References to other flakes can be specified using a dedicated URL-like syntax.
- A flake registry allows using symbolic identifiers for further brevity.
- References can be automatically locked to their current specific version and later updated programmatically.
- A new command line interface, implemented as a separate experimental feature, leverages flakes by accepting flake references in order to build, run, or deploy software defined as a flake.

What’s great about Flakes?

- The flake.nix file is checked for schema validity.
- In particular, the metadata fields cannot be arbitrary Nix expressions. This is to prevent complex, possibly non-terminating computations while querying the metadata.
- The entire flake directory is copied to Nix store before evaluation.
- This allows for effective evaluation caching, which is relevant for large expressions such as Nixpkgs, but also requires copying the entire flake directory again on each change.
- No external variables, parameters, or impure language values are allowed.
- It means full reproducibility of a Nix expression, and, by extension, the resulting build instructions by default, but also prohibits parameterization of results by consumers.

Demo: Nix Flakes

- Let’s take a look at a nix flake

NixOS

What is NixOS?

- A Linux distribution that can be configured and is based on Nix and Nixpkgs.
- Its underlying modular configuration system is written in the Nix language, and uses packages from Nixpkgs.
- Nix is purely configured in the file: `/etc/nixos/configuration.nix`
- The operating system environment and services it provides are configured with the Nix languages

GParted
Install System
Konsole
NixOS Manual
About this System — Info Center
Search...
Basic Information
About this System
System Monitor
Energy
Detailed Information
Devices
Graphics
Network
Copy to Clipboard
6:36 AM
6/1/23

About this System

NixOS 23.05
https://nixos.org/

Software

```
   KDE Plasma Version: 5.27.5
KDE Frameworks Version: 5.106.0
           Qt Version: 5.15.9
       Kernel Version: 6.1.31 (64-bit)
    Graphics Platform: X11
```

Hardware

```
         Processors: 12 × AMD Ryzen 5 4600H with Radeon Graphics
             Memory: 3.8 GiB of RAM
 Graphics Processor: llvmpipe
```

Example Nix Configuration

```nix
{ config, pkgs, ... }:

{
  imports = [ ./hardware-configuration.nix ];

  boot.loader.systemd-boot.enable = true;
  networking.hostName = "my-nixos";
  services.sshd.enable = true;
  users.users.daniel = {
    isNormalUser = true;
    extraGroups = [ "wheel" ];
  };
  environment.systemPackages = with pkgs; [ git vim ];
}
```

Nix Conclusion

Nix Conclusions

- SDKMan and Brew are awesome, **but it is not tied to your project**
- Nix is a development environment
- Nix is not binaries that are packaged, they are recipes
- They are reproducible if versions are pinned
- **Declarative** and **Programmatic**
- **High -- Very High Learning Curve.** But so was everything else we endeavored to learn
- I think it would be good to have more Java representation in the Nix Ecosystem
- You will of course still use docker and devcontainers, it just doesn't have to be for everything

Thank You

- Email: dhinojosa@evolutionnext.com
- Github: https://www.github.com/dhinojosa
- Linked In: http://www.linkedin.com/in/dhevolutionnext