

# Next Steps for Reproducible Testing and Deployment

“The attempt to rewrite the foundations of mathematics in terms of category theory is evil and wrong.” –Walt Pohl<sup>1</sup>

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<sup>1</sup>Attribution: (Pohl 2005)

# Outline

- 1. Why Nix? Some Arguments.**
2. The Great Nixification. An Overview.
3. Related Research Directions
4. References

# 1.1 Nix as the Purely Functional, Monadic Build Tool

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**We want a way to tell computers how to run software,  
and we want software to run the same way on any system, regardless of its  
internal state.**

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- Software has dependencies (for compilation, development, and in production), configurations, targets (supported systems), feasibility relations, and a bunch of other stuff we don't know about ("the world")
- Dealing with dependencies is a very serious problem (packages will require conflicting versions of the same package)



Eelco Dolstra, original Nix theorist

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  - It has a build function that looks like  $g : Y \rightarrow FZ$

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  - The so-called “monadic bind”
- We want a **monadic** build system (“The Postmodern Build System” 2023)
- We want **optimized incremental** builds (i.e. the bind operation should be fast and builds should be **pure**)
  - Same input, same output

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- Some nice properties of **pure builds**  
(the formalism we've been developing for talking about software deployment):
  - Minimal recomputation
    - only the specific dependencies that are changed need to be rebuilt
  - Distributed builds
    - all systems produce the same binaries

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- Nix is not a dogmatic philosophy but the result of logical deliberation over the optimal dependency management scheme
- Nix is the unique existing build system satisfying both a **reproducibility criterion** and having **high interpretability**



## 1.2 Nix as the Fully Reproducible, Interpretable Build Tool



*Figure 1: This is absolutely not true*

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## 1.2.3 Reproducibility

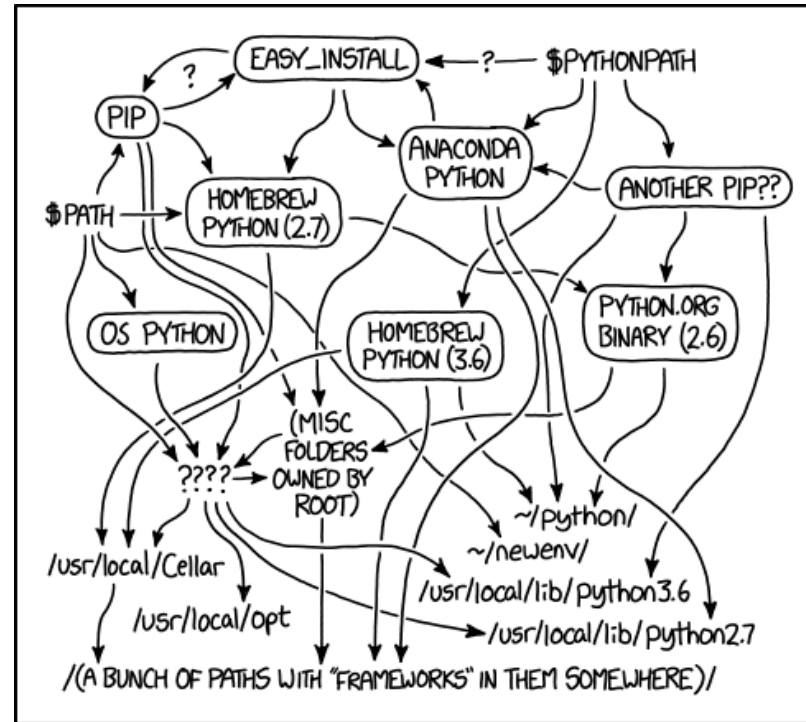
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- Build twice. Any system, anywhere, any time, any [insert here].  
**Same result.**
- Everything can be **built from source**
  - Critical for OPSEC
- Stuff just works.™

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MY PYTHON ENVIRONMENT HAS BECOME SO DEGRADED  
THAT MY LAPTOP HAS BEEN DECLARED A SUPERFUND SITE.

Figure 2: Other so-called "package managers"

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  - About 5x faster compared to the ROS development environment (Purvis and Wanders 2022)

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- Docker comes with supply-side **bloat**, Nix comes with a **minimum package set**
- Docker is **stateful**, Nix is **stateless**

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## 1.2.10 Docker

Reproduce, exactly, the entire system **state** of a working environment

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# 1.2 Nix as the Fully Reproducible, Interpretable Build Tool

## 1.2.12 Docker

Reproduce, exactly, the entire system **state** of a working environment

For Arcturus, this isn't even the same as our deployment environment! This is **very bad**!

We don't know **why or how stuff works**, only that it works on a given system.

Equivalently, any change to the system state (Docker configuration) could lead to critical build failures.

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Reproduce, exactly, the minimum set of **components** (packages and related configurations) that define a working environment

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Reproduce, exactly, the minimum set of **components** (packages and related configurations) that define a working environment

We can ask questions like *which packages does this module depend on?* or *why did this new build fail?*



## 1.3 Nix as the Universal Build Tool

“The category of food,  $\mathbf{F\ddot{U}D}$ , is a full subcategory of the category of stuff,  $\mathbf{St\ddot{U}F}$ , whose objects are the stuff you can eat. A morphism of this category is known as a recipe.”

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Nix is often described as a bad implementation of a good theory, mainly because it has actually been implemented and no longer exists in the minds of category theorists

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- Any project, any dependency, any version
- Nix is extensible enough to describe build recipes for a wide variety of projects, and ROS is no exception
- However, ROS uses infamously bad dependency specifications and runtime environments

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Due to the severe shock that would result from hacking on Nix code in the primary codebase (as is best practice), the Nix build system has been developed completely independently.

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- **Isolated** (self-contained, use it only when you want)

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- **Non-invasive** (using Nix does not interfere with existing working build environments)
- **Isolated** (self-contained, use it only when you want)
- **Verifiable** (benefit from safe binary caching and reproduce tests on other systems)

## 2.1 Non-invasive, isolated, and verifiable

**Flakes aren't real and cannot hurt you: a guide to using Nix flakes the non-flake way**

January 02, 2024 - 26 minute read

Inflammatory title out of the way, let's go.

*Figure 1: tl;dr: you should be using Nix already*

## 2.2 Where we are in relation to the literature

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- A reproducible testing environment for individual nodes
- Preliminary implementation of a binary cache

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### 2.2.4 The literature:



*Figure 2: Grade A level trolling by Motorsports*

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- Presented at ROSCon 2022 (Purvis and Wanders 2022)
- Work undergoing to rewrite [ros2nix](#) in Motorsports
- Failure to keep pace with these developments reduces our research competitiveness, puts our build system in jeopardy of deprecation, and leaves our OPSEC vulnerable to upstream security issues

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- **Gazebo/VRX simulation natively in Nix**

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  - Docking will be a good case study
- Formal verification with Deal
  - Use Haskell or another functional language for rapid theorizing and testing, independent of main codebase
- Fully vision-based autonomous systems
  - Station keeping would make a good R&D study of the feasibility of this



**R&D subteam?**

## 3.3 Further Reading

More to come on this in the future...

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This report is entirely open-access and open-source. You are welcome to contribute.

<https://github.com/arcturusNavigation/tdr>

## 4. References

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Crane, Dana. 2022. “Trust, Security and the Reproducibility Crisis in Software”. February 2022. <https://www.activestate.com/blog/trust-security-and-the-reproducibility-crisis-in-software/>.

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