

Controlling Opaque-Component Effects with Semisolates and Try

<https://binpa.sh/try>

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Abstract

Many developers and systems today rely on opaque software components. When executing, these components affect each other and the broader environment in which they execute. Some of these effects are expected and desired; others not so. This paper introduces semisolates, an abstraction and corresponding subsystem for controlling and manipulating the effects of opaque components. Available as an unprivileged, higher-order, language-agnostic command, `try` interposes on a component’s execution to automatically capture and control its effects. Effect control includes introspection, optional application, effect stacking, and further manipulation—all driven by several real-world case studies. Today `try` is used in research and production applications across several organizations, mediating potentially undesired effects, maintaining full compatibility with real-world components, and incurring a modest performance overhead well within each case’s acceptable levels.

1 Introduction

Modern software systems contain many intercommunicating components, including various subsystems, programs, commands, and packages [11, 44, 45, 93]. These components are often available in diverse programming languages, interact opaquely with the broader environment, and are developed by developers of varying skill and care. Even quick-and-dirty data-processing scripts pull together many polyglot components [44, 71] and simple update scripts or AI agents invoke other commands to complete their jobs [45, 93].

Unfortunately, the execution of these components—during *e.g.*, exploration or development—results in unpredictable and often-irreversible effects. These effects are a direct and necessary byproduct of the computation encoded by a component: executing `npm install` downloads and installs new software packages, directly altering several files and directories [1]. At times, effects are unintentional: naively running a

```
curl -sL https://sh.rustup.rs | try sh semisolate
/bin/, /proc, ... -----> /home/user/.cargo (modified)
/home/user/.cargo/bin/ -----> /home/user/rustup/ (added)
/home/user/rustup/ -----> ✓ /home/user/work/ (added)
/home/user/work/ -----> X /home/user/work/ (deleted)
/etc/passwd -----> X /etc/passwd (hidden)

current environment
```

Figure 1: Applying `try`. Execute a command in its own `try` semisolate to control its effects: inspect, selectively apply, revert, partially hide (all shown) or otherwise manipulate them—all within the *current* environment rather than a new isolated container.

`find -exec` as suggested by an LLM may result in deleting critical user files [52]. These and other cases (§2) hint at the necessity to control these effects during component execution.

This paper presents a new abstraction, the *semisolate* (§3), and corresponding implementation, `try` (§4), for controlling the effects of such opaque components. Semisolates offer the ability to execute a component in the current environment via an unprivileged, language-agnostic, higher-order command that allows its users to inspect and manipulate a completely unmodified component’s externally observable behavior. But rather than focusing on the behavior encoded in standard streams, easily controllable by the usual pipe-and-filter patterns, `try` focuses on *side* effects such as filesystem modifications. And contrary to various forms of containment and virtualization [10, 54, 68], which create a new environment that fully isolates all effects, `try` allows the executing components to access the current environment in which they execute and enables effect manipulation directly in that environment; the term *semisolate* (from *semi-*, meaning “partially,” and *isolate*) reflects this partial rather than complete isolation.

More specifically, `try` allows introspecting, selectively applying, stacking, and further manipulating a component’s effects to the filesystem and the broader environment. To automatically capture these effects, `try` limits the component’s view of the filesystem: it first sets up a *semisolate* to create a view of the filesystem and environment that retains partial isolation; it then executes the component inside the semisolate, collecting effects into a writable temporary directory; finally, either during its (streaming) execution or upon completion, the semisolate allows manipulating the collected effects by

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staging them, reverting them or applying them to the underlying filesystem—either wholly or partially (Fig. 1).

This opaque effect control is applicable broadly (§2): it can be used to inspect the effects of risky or cryptic LLM suggestions before applying them [26]; track the dependency graph for systems composed of opaque components, useful for parallelization or reordering [65]; provide a `--dry-run` capability, found today in some commands, that is general and command-agnostic [89]; and support specification inference for opaque components [45]. These and other examples drive `try`'s design requirements: effect control that allows hiding state, stacking effects, and partially or fully applying or rolling them back. No current abstraction and corresponding subsystem offers granular effect control with `try`'s wealth of features.

Applying `try` to real-world cases (§5) indicates that `try` controls all relevant component effects, maintains behavior equivalence with non-semisolated execution, and incurs a modest performance overhead relative to the needs of each use case. Semisolates and `try` offer a distinct set of features from, and better performance than, container systems such as Docker, OrbStack, and Podman [54], built using similar components arranged quite differently.

In summary, this paper makes several contributions: it

- identifies the shared needs of several case studies for which today's effect control is insufficient (§2);
- presents a novel effect-control abstraction, a semisolate, that meets the needs of these case studies (§3);
- describes the implementation of `try`, a new effect-control subsystem built for Linux environments (§4);
- characterizes `try` by applying it to several real-world components drawn from the earlier case studies (§5).

It also discusses `try`'s limitations and the experiences of organizations using `try` (§6), as well as prior related work (§7). Appendix A contains all LLM prompts used in the evaluation, Appendix B collects several testimonials on `try`'s potential impact, and Appendix C describes the artifact accompanying this paper. The `try` subsystem is open-source, MIT-licensed software, publicly available on GitHub [92].

2 Examples and Goals

To understand the need for controlling component effects, this section describes several real-world case studies (§2.1). Combined, these case studies highlight several shared requirements for the design of a flexible effect-control abstraction and corresponding subsystem (§2.2).

2.1 Motivating Examples

Risky or cryptic LLM suggestions: Recent agentic systems have incorporated large language models (LLMs), allowing them to act on behalf of the developer by executing arbitrary

commands inside the host system [2, 3, 7]. Consider using an LLM to generate a script that “cleans up its containing directory”; it generates `delete.sh` containing the following:

```
rm -fr "$ (cd "${0%/*}" && echo $PWD) "/"
```

Unfortunately, when called from some paths, the runtime expansion `${0%/*}` will expand to the script's path, `cd` will fail, and `rm` will delete everything user-writable. Prefixing this line with `try` indicates the deletion of all user-writable directories and offers the option to discard these changes.

```
1 try sh delete.sh
2 /home (deleted)
3 /etc (deleted)
4 ...
5 Apply these changes? [y/i/N]
```

A developer or system calling `try` can decide whether to inspect these changes and choose to discard them, or inspect them individually and choose which ones to apply.

Dependency tracking: Speculative execution reordering offers significant speedups [65], but ensuring it respects read-after-write dependencies across opaque components is particularly challenging. Consider the following program that compiles three and links two C files:

```
1 gcc -c a.c -o a.o; gcc b.c -o a
2 gcc -c c.c -o c.o; gcc a.o c.o -o b
```

The second call to `gcc` does not depend on the first, thus it can be executed in parallel. Unfortunately, detecting this opportunity automatically at runtime requires detecting effects and postponing their application to the broader environment until they are confirmed to not violate read-after-write dependencies—at times discarding these effects to effectively roll back command misspeculation. Crucially, subsequent invocations must start their execution with the illusion that prior effects have been applied—necessitating chaining reversible effect application across component invocations.

Prefixing `gcc` with `try` while explicitly asking it to stack sets of effects solves both problems:

```
1 try -t trace1.log -N env1 gcc -c c.c -o c.o
2 try -t trace2.log -N env2 -L env1 gcc a.o c.o -o b
```

The `-N` option instructs `try` to store, instead of directly applying, `gcc`'s effects for later use with a configurable name. The `-t` flag enables system-call tracing to capture ordered filesystem effects. Next, `-L` injects `gcc`'s uncommitted effects from `env1` into its own view, making `c.o` visible to `try`'s second invocation.

Third-party library risks: Public third-party libraries amplify developer capabilities, but risk introducing undesired effects [15, 56, 63]. Consider the popular `node-ipc` library [72], invoked as part of a larger codebase:

```
npm test node-ipc
```

Earlier versions of `node-ipc` included undesired effects modifying critical system files [18, 86]. Prefixing `npm test` with `try` highlights files about to be modified without making any modifications prior to approval:

```
1 try npm test node-ipc
2   /etc/passwd (modified)
3   /bin/bash (modified)
4   /sbin/init (modified)
5   ...
6   Commit these changes? [y/i/N]
```

The output of `try` shows all such effects, allowing a developer to review any unexpected effects and, if necessary, selectively apply only the relevant ones. It is also possible to filter or aggregate over the set of effects to make review easier (§6).

Dry-run execution: Some commands offer specially configured dry-run modes (e.g., `--dry-run`, `--fake`, `--no-commit`, `--print`, `--just-print`, `--simulate`, `-n`, `-s`) that show the effects of simulating a command’s execution [67]. Consider an invocation about to clean temporary files in the current directory using `find`:

```
find . -name '*tmp*' -delete
```

Unfortunately, `find` does not offer a built-in dry-run functionality. Prefixing the command with `try -n` instead executes the command in a semisolate, collecting and presenting its actual effects to the user while discarding them.

```
try -n find . -name '*tmp*' -delete
./tmp_build/ (deleted)
./tmp.log (deleted)
```

Using `try`, a user sees the concrete effects that the command’s execution would have produced, even if it does not implement built-in dry-run functionality.

Partial-specification mining: Automated acceleration of programs that use opaque components [38, 71] depends on partial component specifications—e.g., the order in which a component reads its input streams [34]. Generating such specifications automatically requires exploring a command’s invocation space while carefully collecting the effects of different invocations. Consider the following invocation of `grep`:

```
grep -oE [a-zA-Z]+ one.txt two.txt
```

Unfortunately, understanding that `grep` first reads `one.txt` and *then* reads `two.txt` requires a more detailed view of its effects. Prefixing `grep` with `try -t` offers a detailed, ordered log of `grep`’s read and write effects:

```
try -t trace.log grep -oE [a-zA-Z]+ one.txt two.txt
```

The resulting `trace.log` file contains information that can then be compiled into a partial specification for `grep`.

```
1 r /usr/bin/grep
2 r /usr/lib/libc.so.6
3 r one.txt
4 r two.txt
5 w stdout
```

This order of effects extracted by `try -t` reveals invariants (e.g., `one.txt` preceding `two.txt`) that need to be maintained when optimizing programs that invoke `grep`.

2.2 Desiderata for the Missing Abstraction

The aforementioned case studies illustrate an underlying common need to abstract away effect control. A suitable effect-control abstraction has several core requirements: (1, **I**) *effect introspection*, i.e., the ability to detect, collect, present, and inspect a component’s side effects in the same environment directly executing the component; (2, **A**) *selective application*, i.e., the ability to decide whether to apply effects to the broader environment or roll them back; (3, **S**) *effect stacking*, allowing commands to execute in the context of earlier effects that have not been applied yet, potentially rolling back multiple stacks of effects; (4, **M**) *further effect manipulation* beyond direct application or discard, including partial application of only some effects, effect recording and delayed propagation, and selective hiding of the underlying environment. These requirements typically need to be met in the context of the current executing environment—not a virtualized or contained environment fully isolated from the current environment.

Apart from these core requirements, the abstraction’s applicability and reach would further benefit from an implementation that combines streaming support, allowing its users to manipulate the effects of long-running components as they are generated; configurable effect handlers for tuning the granularity of effects; and runtime performance overheads that do not affect interactive use. These features are not essential to the core abstraction—i.e., a batch-only, non-configurable, slow implementation would still fit all of §2.1’s case studies—but they broaden its applicability and reach.

Other characteristics such as complete mediation against arbitrary adversarial behavior are out of scope: the abstraction aims at the inconvenient or undesired effects of everyday mistakes or accidents—not actively malicious, `try`-aware components trying to bypass its underlying mechanisms [49].

3 Abstracting Away Effect Control

To meet the aforementioned desiderata (§2.2) and abstract away effect control, `try` offers a language-agnostic and configurable abstraction that launches one or more components in a semisolate. A semisolate offers a constrained and configurable (Tab. 1) private view of the real host environment—i.e., not a fresh environment in a container or virtual machine. In the example below, `sh` runs in the exact same environment as

Table 1: Control configuration and `try` flags. Controlling effects with `try` supports significant configurability during semisolate creation, execution, and conclusion—including core options (in black, Cf.§3) and peripheral features and subsystems (faded, Cf.§6).

Semisolate stage	Configuration	Flag
Creation	Stack over prior effects	-L
	Name current effect group	-N
Execution	Ignore specific paths	-i
	Disable the network	-x
	Create filesystem trace	-t
	Collect effect delta	--diff
Conclusion	Apply all effects	-Y
	Discard all effects	-n
	Inspect effects	-e
	Include, exclude specific paths	-I, -E
	Summarize effects	-s
	Offer friendlier summary	-h

`curl`, but within a private view that controls, manipulates, and potentially discards the application of effects to the broader environment:

```
curl -sL https://sh.rustup.rs | try sh
```

This private view can be configured to, for example, completely mirror the global filesystem, partially mirror it while hiding subtrees, or correspond to one or more layers of as-yet-unapplied effects from previous `try` executions.

Semisolates: The abstraction of a semisolate provides the illusion of direct access to its outer environment and supports flexible effect manipulation. Semisolates collect the effects of opaque components in this private view and expose them to their callers for further manipulation. Using semisolates, `try` allows its callers to (1) selectively apply or discard these effects, with options to view partial earlier state; (2) collect the effects for possible application later; and (3) stack and expose as-yet-unapplied effects across invocations. This design allows the effect-mediated component to execute in partial isolation, without affecting the global filesystem until the caller explicitly consents.

To achieve effect control, a semisolate operates in three configurable stages: (1) *creation*: the semisolate sets up the appropriate view for the executing component to ensure appropriate effect mediation; (2) *execution*: the semisolate launches the target component within a private view, collecting relevant effects; and (3) *conclusion*: the semisolate optionally and selectively applies recorded effects into the main environment.

All three stages typically operate on the current directory and are highly configurable to support the nuances of various real-world uses (§2). The next few paragraphs detail such tuning, both at the level of individual stages and the current `try` flags summarized in Tab. 1, after first establishing which effects are controllable and their level of control.

Which effects are controllable: Unix and its descendants offer many well-studied, fine-grained tools for the pipe-and-filter abstractions—for program *output*. There are only coarser, less well-studied tools to help manage program *effects*. Analogizing the Unix environment to a single executable, existing abstractions focus on function inputs and outputs (Unix: standard streams, exit status), but not the heap (Unix: the filesystem). Semisolates offer a new, fine-grained tool for effect management. They add abstractions for manipulating effects around a child command—for example, the initial filesystem view, the final filesystem view, and the filesystem access trace. They can optionally be configured to support additional system, network, and stream effects as part of a unified abstraction.

Effects are made available to the semisolate caller as a combination of (1) filesystem paths or stream identifiers, and (2) optional metadata such as effect type and success. Each path can be a valid path pointing to an existing file or directory; it can also be a *non-existent* path that might lead to access failure—still useful when a command relies on a file’s absence to exhibit the intended behavior. The effect type includes information such as read-only, write-only, and read-write: a read-write effect is, for example, opening a file with any flag other than `O_RDONLY`; a read-only effect includes operations that only interrogate a file’s metadata through, for example, `stat`ing a file; a write effect includes modifying filesystem metadata through, for example, `chmod`ing or `unlink`ing a file. Each recorded effect instance is accompanied by metadata that indicates whether an effect succeeded; or—if it failed—the reason for its failure.

By default, `try` manipulates effects across entire process subtrees. For example, if a `try`-controlled process launches a subprocess that writes to the filesystem, then `try` will include those write effects in the group of effects directly available for manipulation. A parent process can also use `try` to wrap and programmatically control child effects.

Semisolate creation: Upon creation, a semisolate configures the private view of the executing component—to allow both stacking the effects of different semisolates and prevent unintended effects (including reads), useful for hiding sensitive information from the executing component. Configuring this initial view translates to setting up a virtual-filesystem environment before any modifications to the filesystem.

Upon creation, semisolates may configure effect stacking and hiding. Stacking configures the component’s initial view to import the effects produced from a previous semisolate. Selective hiding masks certain parts of the underlying filesystem from the executing component, given a specification that describes a filesystem subtree. These are implemented by `try`’s interface as `-L`, which accepts the name of a previous semisolate, itself produced by a previous call to `try` with the `-N` flag; and `-i`, which takes as input a regular expression that matches filesystem paths to be hidden from the component’s view. The latter is semantically equivalent to stacking the

effects of `try -n N rm dir1 dir2... overtry -L N`—but `-i` is more efficient as it directly sets up exclusions without first running an additional (potentially expensive) command.

Semisolate execution: During execution, semisolates additionally configure the classes of effects to interpose on and the corresponding interposition granularity—for example, whether to include system-call tracing. The current classes of effects include filesystem effects, network effects, signals, and interprocess streams.

The current interface of `try` supports: `-t`, which makes `try` produce a filesystem access trace, containing an ordered list of effects; and `-x`, which prevents the component from accessing the network. Apart from the effect path, this detailed view consists of the mode and the return code, which can be inspected to infer negative effects like failed accesses.

Semisolate conclusion: Upon conclusion, semisolates offer the ability to decide which effects to apply and which to discard, eventually generating the final filesystem view. They allow selective effect application at multiple granularities, from binary all-or-nothing to per-effect application, while also supporting path-oriented filtering. They can also hold individual effects and allow inspecting them directly using conventional Unix abstractions.

These options can be configured when a semisolate concludes. The current interface supports inspecting individual effects (`-e`) and, based on predefined caller policies, programmatically filtering these changes (`-E` and `-I`). It also supports applying, discarding, or mixing them (`-y`, `-n`, and `-e`). And `-N` stores effects in a named effect directory, potentially used earlier during creation with `-L`.

4 The Try Subsystem

This section describes how `try` implements the aforementioned abstraction (§3) for programs executing in Linux userspace. It first outlines `try`'s use of union filesystems, namespaces, and system-call tracing before diving into the details of semisolate creation (§4.1), execution (§4.2), and conclusion (§4.3), closing with a detailed walkthrough of multiple `try` invocations put together (§4.4).

Union filesystems: To achieve effect control, `try` needs to interpose on the component's view of the filesystem. This interposition is responsible for manipulating the underlying filesystem view, creating a partially private view that allows accessing the underlying contents while capturing and containing effects. This private view is implemented as a union filesystem, configured appropriately to either mirror the underlying filesystem, partially mirror it with sensitive paths hidden, or correspond to the as-yet-uncommitted state of a previously executed run of `try`. To contain effects, `try` uses the configured union filesystem to record filesystem changes into a temporary directory—without affecting the *host environment* until effects are applied.

To instantiate the concept of effect *layers*, `try` leverages OverlayFS—a specific implementation of a union filesystem part of the Linux kernel [24]. Union filesystems are a class of filesystems that allow multiple directories to be presented as a single unified directory without modifying the underlying kernel structures [70]. A union filesystem layers an upper directory (*upperdir*) and one or more lower directories (*lowerdirs*) into a single merged view—without merging their underlying data.

In the merged view, the content at a specific path `p` is determined by searching for `p` in the *upperdir*, followed by all *lowerdirs* in order until `p` is found. The first match is presented in the merged view; if `p` exists in multiple layers, content from the higher layer takes precedence.

Changes to the merged view are forwarded to the *upperdir* and persist inside it, even after unmounting the union filesystem directory. Changing a file at `p` in the merged view places the new version of the file at `p` in the *upperdir*. Removing `p` places a *whiteout file* at the corresponding *upperdir* location.

Namespaces: To execute privileged actions—while executing in an unprivileged manner—and interpose on the execution context of the component, `try` leverages Linux process namespaces. Namespaces isolate resources such as the network, pseudo-filesystems like `procfs`, permissions, and signals from the rest of the system, offering (groups of) processes the illusion of exclusive ownership of those resources—enabling the creation of a private (and controllable) view of the underlying system state. For example, the PID namespace assigns new PIDs to processes inside the namespace: processes in the namespace can only see and interact with each other using the PIDs assigned in the namespace.

Process-related interactions such as signaling between processes and adjustment of scheduling priorities are contained to the namespace. Components in `try` are only partly able to interact with ambient resources and objects such as processes, users, or network devices—with `try` interposing on all accesses to the broader system.

System-call tracing: To observe the order of a component's effects, and go beyond effects that modify the filesystem, `try` leverages system-call tracing—interposing between the operating system kernel and user-space components to monitor and record their interactions. Tracing commands such as `strace` on Linux offer visibility into exact calls performed by a process, their order, and their arguments, as well as the signals received by the process. Combined, they offer a wealth of information about the process—including filesystem operations, process management, inter-process communication, and network access. By selectively enabling tracing when necessary, `try` extracts ordered, finer-grained information about component effects beyond filesystem modifications.

Algorithm 1 Semisolate creation. Key steps in setting up a new semisolate, before running a component;

Require: *path*

```
1: if path is not provided then
2:   path ← mktemp -d
3: end if                                ▷ Set up directories
4: if path's filesystem is overlayfs then
5:   mount -t tmpfs tmpfs path
6: end if
7: for all dir in topLevelDirs do
8:   mkdir -p path/upperdir,workdir,tmp/dir
9: end for
10: unshare ...                            ▷ Prepare namespaces
11: for all dir in topLevelDirs do
12:   mount -t overlayfs ...path/tmp/dir
13:   if overlay failed then
14:     mergerfs path/tmp/dir...
15:     mount -t overlayfs...path/tmp/dir
16:   end if
17: end for
18: mount path/tmp/dev/...                ▷ Mount devices
19: unshare ...                            ▷ Enter environment
```

4.1 Semisolate creation

Each semisolate uses its own special writable directory to record effects—the `upperdir`—and a second temporary directory—the `workdir`—used by the union filesystem for internal bookkeeping (Alg. 1, lines 1–5). Each of these directories can be (1) a new, appropriately prefixed temporary directory created with `mktemp`; (2) a new directory whose name is provided by the `try` caller; or (3) an existing directory, potentially used in previous `try` invocations.

OverlayFS does not support certain filesystems to host the `upperdir` or the `workdir`. One such filesystem is OverlayFS itself, a common scenario when using `try` within Docker. In this case, `try` mounts an additional `tmpfs` over the semisolate directory (Alg. 1, line 5). This ensures that all of `try`'s side effects prior to the conclusion stage are confined within the semisolate directory.

Setting up mounting options: To bypass OverlayFS's restriction of overlapping the lower and upper directory, `try` creates an individual union filesystem mount for each top-level directory—e.g., `/bin`, `/usr`, and `/home`—instead of using the root directory `/` as the union filesystem's lower directory.

Specifically, `try` first creates directories `upperdir`, `workdir`, and `tmproot` (Alg. 1, lines 5–12). In these top-level directories, it then creates a child directory for each top-level directory in the filesystem, such as `/etc`, `/usr`, and `/home`. Additional lower directories already containing effects are added to the mount options during this step—layered on top of the corresponding union filesystem merged views. The `tmproot` directory will become the final merged view pre-

sent to the executing component (§4.2).

Once inside the new namespace, `try` iterates over the mount options constructed in the previous step and mounts the union filesystem (Alg. 1, lines 12–14). It mounts the `/proc`, `/dev`, and `/devpts` pseudo-filesystems within the `tmproot` directory and symlinks all special files through which the component interacts with its standard input and output streams—i.e., `/proc/self/fd/{0,1,2}` and `/dev/{stdin,stdout,stderr,fd,pts}`. Using `bindmounts` [23], it duplicates device files such as `zero`, `null`, and `random`, into the `tmproot`'s `/dev` directory.

To implement file hiding, `try` creates an additional directory called `exclmdir`. This `exclmdir` directory is mounted as an intermediate layer right above the lower directory and contains whiteout files corresponding to files that will be hidden from the merged view.

Submount permissions: Unfortunately, filesystem submounts within any OverlayFS layer cannot be unmounted by the current user: mount points inside layers are ignored because these layers correspond to overlapping filesystem fragments. Consider an initial filesystem *A* that contains paths `/x`, `/x/y`, and `/x/y/z`, and a new filesystem *B* mounted at `/x/y`, effectively hiding `/x/y/z` as contents at that mount point by *B*. If `/x` is specified as an OverlayFS lower directory, it will include only the contents of *A* and ignore the submount to *B*—thus including `/x/y/z` in the merged view.

As `try` aims to limit access to information otherwise inaccessible without its use, it prevents unprivileged access to directories with submounts as lower or upper layers. Although the fresh mount namespace grants `try` the capability to create new overlay mounts, among other root-like capabilities, it is forbidden to unmount existing submounts.

To address this problem, `try` uses an additional union filesystem to “flatten” all content within the directory into a single filesystem (Alg. 1, line 14) when submounts are present. The union filesystem used by `try` for this purpose is `mergerfs` [62], which combines the entire directory, including its submounts, into a single, unified filesystem view. This contrasts with OverlayFS, which does not support submounts. By creating this flattened view of the directory, submounts are effectively eliminated, allowing OverlayFS to use the directory as a `lowerdir` without issues.

4.2 Semisolate execution

After preparing a semisolate, `try` launches the effect-controlled component in its own dedicated namespace and optionally traces its execution.

Execution namespacing: The semisolate executes components within a new user, PID, mount, and network namespace (Alg. 1, line 10). There are two distinct reasons for which `try` uses namespaces: (1) namespaces offer controlled isolation from the broader environment, restricting the process's view so that all effects—together with the filesystem

tem view shaped by the semisolate (§4.1)—are contained, (2) namespaces create the illusion of administrative privileges, allowing a semisolate to mount `/proc` and the union filesystem itself, which would otherwise require elevated privileges. The capability for user namespaces requires setting the `unprivileged_usersns_clone` kernel flag, enabled by default in most modern Linux distributions and depended on by container runtimes like Podman [30]. This avoids the need to implement `try` as a `setuid` binary requiring elevated privileges to execute.

Finally, `try` enters a second new namespace (Alg. 1, line 19) to isolate the component’s process tree from `try`’s own process, setting the component’s root directory to `tmproot` using `unshare`, and finally executes the component under optional system-call tracing.

Execution tracing: To extract additional information about filesystem effects, `try` can interpose on relevant system-call invocations using `strace`. Rather than tracing all filesystem-related system calls when they occur, `try` focuses on collecting relevant information upon `open`—as this is typically a necessary step before subsequent operations on the file descriptor such as reads, writes, random accesses, or direct memory mapping. This approach lowers `try`’s performance overhead, as it avoids tracing reads, writes, and other latency-critical data manipulation operations, omitting further tracing during subsequent use of the file descriptor.

To improve its reach while still avoiding finer-grained tracing, `try` additionally traces other system calls that take paths as arguments—*e.g.*, `open`, `mkdir`, and `unlink`. To trap only this preconfigured set of system calls, `try` uses Seccomp-BPF [42] with a predefined filter—but allows users to pass additional filters if they need to track additional effects, including operations on already-opened file descriptors.

Non-existent paths: Non-existent or missing paths pose a challenge, as ignoring their accesses risks introducing effect holes: accessing non-existent paths generates an observable effect—*e.g.*, negative return value from `open`. Therefore, `try` records such accesses as negative dependencies. Such negative dependencies are useful for recording effects of searching dynamic library paths and configuration files.

4.3 Semisolate conclusion

Semisolates conclude their execution by going through all the effects in the `upperdir` and either applying predefined policies or logging effects to one of the standard streams. As all changes are captured in the effect directory, applying these effects amounts to carefully comparing the captured effects to the underlying filesystem and environment.

To apply filesystem-related effects, `try` recursively processes the upper directory in a preorder fashion, moving files out of the semisolate and into the real filesystem by handling directories before their contents. For regular files in the upper directory, `try` replaces the original file with the

new file. For directories, it either (1) replaces the original file with the new directory, if a regular file exists at the directory’s original path; (2) replaces the original file or directory with the new file, if the directory has the extended attribute `user.overlay.opaque`, indicating that directories in lower layers have been shadowed by new definitions in the merged view; or (3) replaces the original directory with the new directory. For symlinks, it removes any existing file at the original path and recreates the symlink with the same target as the one in the upper directory. If `try` encounters a whiteout file—a character device with 0 major and minor numbers—in the `upperdir`, it deletes the original file or directory at that path.

If the semisolate directory resides on the same filesystem as the target location, `rename` is used to avoid unnecessary disk copying. Otherwise, `try` falls back to the host’s `mv` utility.

4.4 Putting it all together

Fig. 2 illustrates the internals of four `try` invocations.

The first invocation wraps p_1 , eliding all network access inside the semisolate. It prepares an overlay layer with a whiteout mask at path π , and mounts it on top of the host filesystem’s `lowerdir`, ignoring the underlying π in the filesystem. It then enters the new namespace, and launches p_1 inside it. While p_1 is running, `try` captures five effects in the `upperdir`, which it later processes to summarize the order of effects ($-t$): (1) reading α hits the `lowerdir`, which forwards the call to the underlying filesystem, (2) writing to β hits the `upperdir`, copying β there, (3) reading β hits the `upperdir`, which sees the latest write, (4) reading path π , masked in the overlay layer, thus failing and resulting in `try` recording a negative dependency; and deleting path δ , which places a mask file at δ in the `upperdir`, effectively hiding it from the merged view. The sequence of collected effects ($\alpha_R, \beta_W, \beta_R, \pi_R, \delta_D$) is fed to `stdout` but the effects themselves are discarded alongside the semisolate ($-n$).

Next, `try` wraps p_2 , creating a new namespace and mounting the host filesystem inside a fresh overlay filesystem `lowerdir`, now without any path masking or network isolation. The three component effects it captures are: (1) writing β , with identical effects as before, (2) writing ψ , and (3) deleting δ —both operations captured in the `upperdir`. This time, `try` stores the semisolate (and by extension, its effects) inside a named directory on the host filesystem ($-N \sigma$), after filtering out excluded effects ($-E \psi$) by iterating over the `upperdir` and deleting them.

Next `try` wraps p_3 while stacking the effects of the latest `try` invocation ($-L \sigma$). It captures: (1) writing α , which brings it to the `upperdir`, (2) reading β , which hits the stacked `lowerdir` from semisolate σ , and (3) writing π —recorded in the `upperdir`. The effects stored in the semisolate are the two writes to α and π , and the delete of δ inherited from σ .

Finally, `try` commits the effects ($-y$). It iterates from bottom to top, first applying the effects from the stacked semiso-

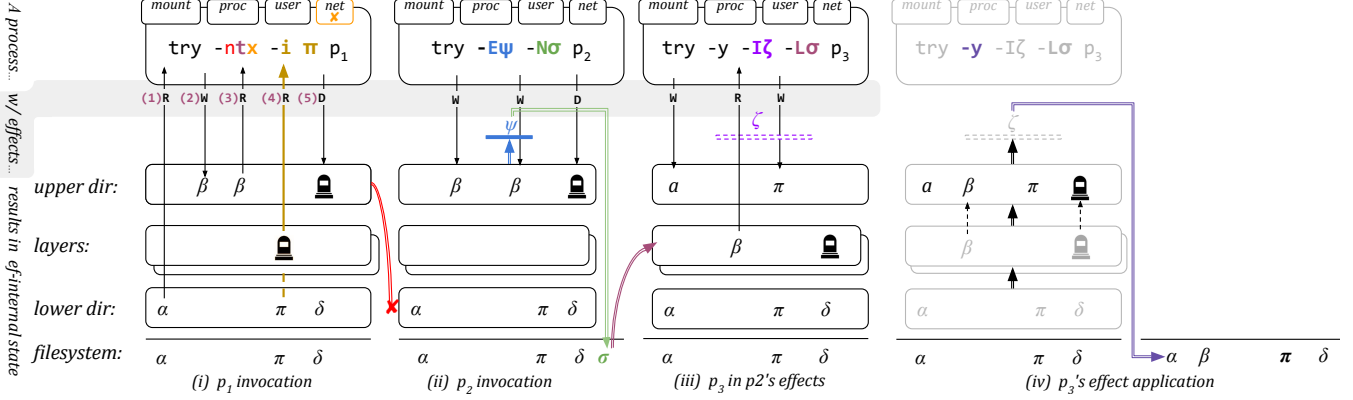


Figure 2: Detailed walkthrough of the internals of multiple `try` invocations. A detailed walkthrough of these invocations is presented in §4.4. From top to bottom: `try`'s invocation, component effects, `try` internal state, and host filesystem state. From left to right: different `try` invocations on different components on the same host filesystem. Single arrows indicate effects; double arrows indicate effect discard, storage, stacking, and application; and certain colors correspond to certain `try` invocation options.

late σ , followed by the current semisolate's effects, applying each one based on its type. It focuses on paths in ζ ($-\Gamma \zeta$), *i.e.*, the writes to β and π , which are applied to the host system.

This approach implements the semisolate abstraction, allowing for effect control on arbitrary components without requiring any invasive instrumentation or modification.

5 Evaluation

This section reports on the results of applying `try` in several instances of each case-study application presented earlier (§2). Key dimensions of each study's characterization (§5.1–5.5) include (1) `try`'s ability to *control* all relevant effects; (2) `try`'s behavioral *equivalence* to semisolate-free execution when effects are finally applied to the host environment; and (3) `try`'s runtime *performance* relative to semisolate-free execution and full isolation (§2.2). A series of microbenchmarks zoom into `try`'s sources of overhead (§5.6).

Control focuses on confirming that `try` correctly identifies \mathbf{I} , applies or discards \mathbf{A} , selects \mathbf{S} , or manipulates \mathbf{M} all relevant effects during a component's execution in a semisolate.

Behavioral equivalence focuses on confirming two aspects of `try`: (1) the in-semisolate behavior during execution, meaning that the computation in the semisolate executes as expected and produces results identical to the non-semisolated execution; and (2) the eventual state of the filesystem, meaning that the filesystem state is indistinguishable from `try`-free execution. The former confirms that `try` does not affect the internal computation, including its direct effects; and the latter confirms that it correctly applies the manipulated effects.

Performance characterization compares runtime without isolation, with `try`, and with Docker v28.4.0 configured with full isolation; performing container (not image) creation, input copy-in, execution, container teardown, and copy-out. Experiments use an environment with 64 GB of RAM and an 8-core

3.70 GHz Intel Xeon W-2145. Software used is the Linux kernel v6.1 on Debian GNU/Linux 13 (trixie), GNU coreutils v9.7, Node.js v18.19.0, and Python v3.13.5.

Benchmark results are summarized in Table 2. In terms of effect control, `try` mediates desired effects, propagates them appropriately, and hides sensitive environment state. In terms of behavioral equivalence, `try` behaves equivalently to `try`-free execution, confirmed both via manual inspection and automated checksum comparison between the entire filesystem tree after executing each benchmark with and without `try`. In terms of performance, `try` incurs a $1.0\times$ – $8.3\times$ performance overhead over vanilla, `try`-free execution and enjoys a $1.1\times$ – $225.7\times$ performance improvement over containment in Docker. We do not provide a geomean or other statistical summary for overhead over vanilla execution or speedup over Docker, as each case study requires different semisolate configurations and corresponding `try` flags to control effects—and thus incur different overheads.

We discuss the benchmarks grouped by use case below.

5.1 Risky or cryptic LLM suggestions

These benchmarks consist of five scripts generated by ChatGPT for tasks distilled from a survey of LLM-mediated workflows, spanning conventional chat interfaces and autonomous agents such as Codex and OpenClaw [82] (prompts included in Appendix §A): (1) **crawl**, updates the timestamps of 10,000 files in a directory, using `find`, `exec`, and `touch` [90]; (2) **fresh**, compressing 10,000 10KB files that exceed a certain size, using `find`, `exec`, and `gzip` [35]; (3) **archive**, searching for files with a `.txt` extension in 100 directories of 10,000 files each, using `find` [37]; (4) **logs**, checking for errors in a 10-million-line file using `grep` [40]; (5) **order**, sorting a 10-million-line file using `sort` [6]. Benchmarks were executed with `try -y` and `try -n`.

Table 2: Benchmark summary. The benchmark applications for the five use cases evaluated. The **Control** column indicates `try`’s effect control between effect introspection (**I**), application and discard (**A**), stacking (**S**), and manipulation (**M**). The **Equivalence** columns indicate whether the output (O) and side effects (SE) match those of vanilla execution. The **Performance** columns show the **execution time ratio** relative to the baseline (Docker or Vanilla), and whether `try` comparatively has a speedup (\uparrow) or slowdown (\downarrow). The **Description** column describes each benchmark’s purpose and `try`’s invocation. The **Source** column provides references to the original benchmark sources.

Use case	Name	Control		Equivalence		Performance vs.		Description	Source
				O	SE	Docker	Vanilla		
Risky or cryptic LLM suggestions (§5.1)	crawl	✓	I A M	✓	✓	1.4 × \uparrow	1.4 × \downarrow	<code>try</code> LLM-generated shell pipelines	[6, 35, 37, 40, 90]
	fresh	✓	I A M	✓	✓	1.3 × \uparrow	1.8 × \downarrow		
	archive	✓	I A M	✓	✓	225.7 × \uparrow	1.3 × \downarrow		
	logs	✓	I A M	✓	✓	58.2 × \uparrow	1.9 × \downarrow		
	order	✓	I A M	✓	✓	2.0 × \uparrow	1.1 × \downarrow		
Dependency tracking (§5.2)	covid	✓	I A S M	✓	✓	1.5 × \uparrow	1.0 × \downarrow	<code>try -t -L</code> Script with dependency tracking	[13, 19, 41, 94, 95]
	nlp	✓	I A S M	✓	✓	3.4 × \uparrow	1.2 × \downarrow		
	spell	✓	I A S M	✓	✓	2.3 × \uparrow	1.0 × \downarrow		
	unixfun	✓	I A S M	✓	✓	18.7 × \uparrow	1.7 × \downarrow		
	ci-cd	✓	I A S M	✓	✓	1.1 × \uparrow	1.0 × \downarrow		
Third-party library risks (§5.3)	LinOTP	✓	I A M	✓	✓	2.0 × \uparrow	1.2 × \downarrow	<code>try -i</code> Git repos with risky pre-commit hooks	[8, 28, 64, 66, 73]
	frogmouth	✓	I A M	✓	✓	4.2 × \uparrow	1.0 × \downarrow		
	kibble	✓	I A M	✓	✓	1.4 × \uparrow	1.2 × \downarrow		
	okteto	✓	I A M	✓	✓	1.7 × \uparrow	1.3 × \downarrow		
	uv-metrics	✓	I A M	✓	✓	3.1 × \uparrow	1.0 × \downarrow		
Dry-run execution (§5.4)	git	✓	I A	✓	✓	3.2 × \uparrow	69.8 × \downarrow	<code>try -n</code> Dry-run command invocations	[27, 31, 32, 75, 96]
	patch	✓	I A	✓	✓	3.0 × \uparrow	82.6 × \downarrow		
	rename	✓	I A	✓	✓	2.8 × \uparrow	4.9 × \downarrow		
	rsync	✓	I A	✓	✓	1.2 × \uparrow	7.8 × \downarrow		
	stow	✓	I A	✓	✓	2.8 × \uparrow	6.3 × \downarrow		
Partial-specification mining (§5.5)	cp	✓	I A S	✓	✓	2.2 × \uparrow	8.3 × \downarrow	<code>try -t</code> Standard Unix utilities	[38, 71]
	ls	✓	I A S	✓	✓	1.9 × \uparrow	3.7 × \downarrow		
	rm	✓	I A S	✓	✓	1.6 × \uparrow	7.1 × \downarrow		
	sed	✓	I A S	✓	✓	1.9 × \uparrow	8.1 × \downarrow		
	xargs	✓	I A S	✓	✓	1.6 × \uparrow	1.7 × \downarrow		

Control: All computations executing in semisolates configured with `try -n` mediated all effects that were applied to the filesystem by `try-free` executions.

Equivalence: All computations executing in semisolates configured with `try -y` produce correct results; and their effects on the filesystem are identical to `try-free` executions.

Performance: When compared to vanilla execution, `try` introduces runtime overheads 1.1×–1.9×. Variations come from the complexity of effects interposed during execution. For example, in **order**, `try` achieves the lowest overhead (1.1×) as it interposes on a single write effect, writing the sorted file to disk. The **crawl**, **fresh**, and **archive** tasks exhibit higher overheads (up to 1.9×) because they operate on many files from the host system (use of `find`), which results in more upperdir copy-ups. Relative to Docker-contained execution, `try` demonstrates substantial performance improvements across all five benchmarks, achieving performance improvements of 1.3×–225.7×. Two benchmarks incur outlier speedups: the **archive** benchmark only interacts with its

standard output stream (`find`’s output) which is effectively a symlink to the same file descriptor in the host environment, meaning that `try` boils down to vanilla execution, paying only the flat cost of semisolate creation, while Docker still pays the full container setup and teardown costs. Similarly, the **logs** benchmark reads from and writes to a single large file, meaning that again `try` pays only a single creation and copy-up cost, while Docker with full isolation needs to pay the copy-in and copy-out costs as well.

5.2 Dependency tracking

These benchmarks consist of several real-world shell programs from the Koala suite [44] with many and complex runtime dependencies between their components. (1) the **covid** benchmark, which processes bus schedule data collected during COVID-19 to generate summary statistics [94]; (2) the **nlp** benchmark, which performs natural language processing tasks on a text corpus [41]; (3) the **spell** benchmark, which

checks spelling in a large text file [13]; (4) the **unixfun** benchmark, which solves challenges from Unix 50th anniversary game [95]; and (5) the **ci-cd** benchmark, which compiles several C source files [19]. These programs contain a diverse set of commands that include GNU Coreutils, POSIX, and third-party commands. To stack effects across all component invocations without applying them on the host environment (§2.1), `try` was configured with `-L` and with `-t` to extract dependencies.

Control: All computations executed with `try -t -n -L` mediated all effects that were applied to the filesystem by `try-free` executions. Manual inspection and multiple re-executions confirm that executing these benchmarks with `try -t -L` identifies all true dependencies between components.

Equivalence: Tracking the dependencies discovered by `try -t` and later applying them with `try -y -L` produces correct results. Their effects on the filesystem are identical to the ones produced by `try-free` executions.

Performance: When compared to vanilla execution, `try` introduces absolute overheads $1.0\times$ – $1.7\times$, which is the flat cost of setting up the semisolate environment for each tracked command. However, while the semisolate setup cost is flat, tracing overheads scale with the number of effects a component produces. This is less evident in statically compiled components, such as commands from GNU coreutils, which are tightly packed binaries with very minimal dependencies (often just `libc`), but evident with components relying on interpreted runtimes (e.g., a custom `lowercase.py` utility in `nlp`), which need to resolve their entire dependency tree during execution. The performance of `try` significantly outperforms fully-isolated execution across all five dependency tracking benchmarks, demonstrating speedups $1.1\times$ – $18.7\times$.

5.3 Third-party library risks

These benchmarks consist of `git` repositories with pre-commit hooks that introduce undesirable effects: (1) **LinOTP** [64] multi-factor authenticator; (2) the **frogmouth** [28] markdown reader; (3) Apache **kibble** [8] aggregating and visualizing software data; (4) the **okteto** [66] container orchestrator; and (5) **uv-metrics** [73], a machine-learning metrics reporter. The pre-commit hooks perform several operations on the filesystem, communicate with the network, and include a code-injection attack that leads to data exfiltration. They were prefixed with `try -i`, excluding the `/etc/passwd` file from the semisolate.

Control: All computations executed with `try -i` mediated across all effects present in the `try-free` executions, except `/etc/passwd`. This effect originated from the pre-commit hook at `.git/hooks`, which attempted to append `/etc/passwd` to `README.md`.

Equivalence: All computations executed with `try -i` pro-

duce correct results, correctly committing the intended changes, and the resulting filesystem state remains identical to that of `try-free` execution. Across both the vanilla pre-commit hook workloads and the five code-injection vulnerabilities evaluated, `try` preserves correctness.

Performance: When compared to vanilla execution, `try` has a performance impact of up to a $1.3\times$. The performance of `try` is comparable to vanilla execution for the **frogmouth** and **uv-metrics**, while maintaining low overheads for **LinOTP** ($1.2\times$), **okteto** ($1.3\times$), and **kibble** ($1.2\times$), whose pre-commit hooks perform short-running computations, comparable with `try`'s semisolate setup overhead. It outperforms Docker-contained execution across all five benchmarks, achieving speedups $1.4\times$ – $4.2\times$. With blocking enabled, `try` reduces the effect surface and thus computation performed by the injected pre-commit hooks. This leads to `try` improving the runtime of the **frogmouth** and **kibble** workloads by $0.8\times$ and $0.9\times$ respectively.

5.4 Dry-run execution

These benchmarks consist of commands with built-in dry-run functionality: (1) **git** [31], using `git clean`; (2) **patch** [32]; (3) **rename** [96]; (4) **rsync** [75]; and (5) **stow** [27]. Each workload was executed twice: once with dry-run enabled, without `try`; once with `try -n`, without dry-run.

Control: All computations executed with `try -n` except two mediated on and reported the exact same effects as the corresponding `--dry-run` executions. One of the two exceptions was **rename**: instead of reporting `a -> b`, `try` reports equivalent `a (deleted) b (created)` pairs.

The second exception is more interesting: when combined with the `--log-file` flag, **rsync**'s dry-run mode omits effects in the produced log file [74], whereas `try` captures and reports all produced effects.

Equivalence: All computations executed with `try -n` correctly suppress all effects to the host environment and present the same output and side effects as the dry-run executions (excluding **rename**'s representation difference). Invocations executed with `try -y` correctly apply all effects to the host environment, equivalent to `try-free` execution.

Performance: When compared to dry-run execution `try` demonstrates overheads of $4.9\times$ – $82.6\times$. These overheads are expected since each command's native dry-run mode avoids performing any filesystem action and is implemented as a separate path that does not perform any effectful computation (average time 0.03s), whereas `try` executes the real computation and then discards its effects (average time 0.26s). Compared to full isolation in Docker, `try` improves performance across all five benchmarks between $1.2\times$ – $3.2\times$.

5.5 Partial-specification mining

These benchmarks evaluate `try`'s capability to support automatic specification mining for shell commands, focusing on determining the order of their read and write effects to their standard streams or the filesystem. These properties correspond to the ones required by PaSh [38] and POSH [71] to parallelize or distribute shell scripts. The commands evaluated in this section are: (1) `ls`, a command that lists directory contents; (2) `cp`, a command that copies files and directories; (3) `rm`, a command that removes filesystem entries; (4) `sed`, a stream editor that filters and transforms text; and (5) `xargs`, a higher-order command that executes command lines from standard input. The specification miner explores 11, 100, 40, 1408, and 3 configurations for these commands respectively. For `xargs`, it uses the `rm`, `ls`, and `cat` commands as arguments. All workloads were executed using `try -t`.

Control: All computations executed with `try -t` mediate all observed effects, capturing every read and write operation performed by the evaluated commands.

Equivalence: All computations executed with `try -t` produce correct results, and the resulting filesystem state remains identical to that of `try-free` execution. Across all commands evaluated, the inferred specifications match or extend PaSh's handwritten specifications. In three cases, `try` enables the miner to detect effects omitted from the original PaSh specifications. For example, although `cp` is marked as side-effectful in the original specifications, its behavior in these evaluation scenarios is effectively pure, as it modifies only files explicitly listed in its arguments.

Performance: Since the configuration miner needs to explore a large number of command invocations to infer their specifications, `try`'s overheads compound significantly. Compared to vanilla execution, `try` increases execution time $1.7\times$ – $8.3\times$, caused by `try`'s flat cost of setting up the semisolate environment and its tracing overhead. Vanilla execution is not meaningful in this use case, as the specification miner needs to observe effects to infer specifications. The performance of `try` improves relative to Docker-contained execution across all five mining benchmarks, achieving speedups $1.6\times$ – $2.2\times$. Benefits from `try`'s lighter semisolate setup and teardown times compound over the many invocations required by the specification miner (here, 1562 in total).

5.6 Microbenchmarks

The goal of the set of microbenchmarks is to analyze `try`'s sources of overhead. These benchmarks consist of three workloads: (1) `echo`, a Rust function that creates zero files, invoked 100 times; (2) `files`, a Rust function that creates 10,000 small files of size 16 bytes each; and (3) `big_file`, a Rust function that creates five large files of size 1GB each. All workloads were executed using `try -y` and `try -n`, yielding complete control and equivalence, thus we focus

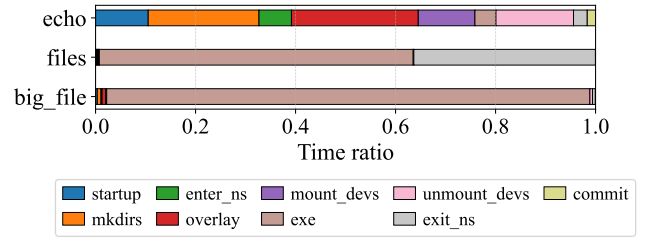


Figure 3: The performance breakdown of `try`. The performance of `try` in three microbenchmarks and its overhead breakdown across different execution stages.

on performance breakdown (Fig. 3).

The performance analysis breaks down the `try` runtime into nine stages: (i) `startup` parses command-line arguments and enumerates top-level directories; (ii) `mkdirs` provisions the upper, work, and temporary directories; (iii) `enter_ns` creates a fresh namespace; (iv) `overlay` establishes the OverlayFS mount points; (v) `mount_devs` bind-mounts selected device files; (vi) `exe` executes the target process; (vii) `unmount_devs` unmounts the device files; (viii) `exit_ns` exits the namespace, triggering the automatic unmount of remaining OverlayFS layers; and (ix) `commit` moves output files from the upper directory to the host filesystem. For the baseline `echo` command, which completes in 165ms, the overhead is caused by filesystem and namespace operations. Creating the OverlayFS (`overlay`) accounts for 25% (42ms), followed by directory creation (`mkdirs`) at 22% (37ms). Device management also creates measurable overhead, with `unmount_devs` taking 16% (26ms) and `mount_devs` taking 11% (19ms). In longer-running benchmarks, such as `big_file` (9.2s) and `files` (11s), these setup and teardown costs remain roughly constant, making the relative overhead comparable to the actual `exe` time. However, `files` presents an outlier in the teardown phase as `exit_ns` takes 6.3s. This latency is caused at semisolate conclusion because `try` needs to iterate over the many files created in the OverlayFS `upperdir`.

6 Discussion, Limitations & Experiences

Limitations: Current `try` limitations primarily impact compatibility in specific scenarios: restrictions and altered application behavior due to its use of user namespaces, challenges in handling pseudo-filesystems and physical devices, and inability to fully disable certain isolation mechanisms.

Due to its use of user namespaces, `try`-semisolated processes cannot interact with other users. Even when a process appears to be root in the namespace, it cannot switch UID or operate on files owned by other users. Components that rely on creating or switching users may behave unexpectedly.

Processes inside semisolates bypass writable permissions without needing to change the file permissions (a special

feature of UID 0 in Linux). This may affect components that rely on write permissions or ones running without elevated privileges, such as `npm`, when the user ID is 0.

As `try` requires user and PID namespaces for unprivileged OverlayFS mounting, it creates a non-configurable isolation barrier for IPC mechanisms such as signals, complicating interprocess coordination when such isolation is not desired.

External modules: Two additional modules augment `try`. For namespace-local root-like capabilities without host root privileges, `try` maps the current effective UID and GID to the superuser inside the new user namespace. Because `unshare` cannot map multiple UID or GID ranges, traversing directories owned by another accessible GID can trigger `EOVERFLOW`; `try-gidmapper` addresses this case, with security implications that go beyond `try`'s current scope.

As the number of effects can overwhelm a user, an external `try` module summarizes effects in a human-friendlier form. This module, called `try-summarize`, queries an opaque language model with the output from `try` and additional instructions requesting (1) a non-expert summary of the effects, starting from the most important ones; (2) information about whether these effects touch sensitive directories. Both prompts offer functionality `try`'s users could directly implement, but proved useful during recent user interactions with `try`.

Experiences: Colleagues and students using `try` have shared several notable experiences (see Appendix B for testimonials unrelated to the `try` authors). The `try` subsystem is also used in several research projects. An out-of-order execution engine called `hS` [48] and a bolt-on incrementalization system called `Incr` [99] use `try` to build a dependency graph between opaque components during execution and revoke their effects when appropriate. They achieve speedups of up to $9.3\times$ and $373.3\times$ over vanilla execution, respectively.

Users often discard effects when the wrapped component wrote outside the expected filesystem subtree, *e.g.*, creating auxiliary files in the home directory, or when its set of effects was larger than expected, *e.g.*, `chmod +x *` affecting all files in the current directory. In several cases, they discarded the effects of mistyped `pip` and `cpnm` invocations. A colleague, after running a training job under `try`, inspected the produced checkpoint files and selectively committed only the highest-performing one. A teaching assistant used `try` to shield against unintended effects from student submissions. Several students have used `try` to interpose on agentic workflows, wrapping their session with `try` and inspecting all produced effects before committing them. Even when the agent performed non-filesystem accesses (*e.g.*, access to webpages, interactions with email and messaging APIs), which often were read-only network effects, `try` remained useful. It allowed students to mediate all resulting local filesystem effects, critical when the agent performed an incorrect action based on misleading information it fetched from the web.

It is possible for users to arrive at an inconsistent set of updates when selectively applying or reordering effects. For

example, the effect of creating file `f` in directory `d` depends on the effect of creating directory `d`. When `try` applies an inconsistent update, it issues a warning similar to standard filesystem manipulation commands (*e.g.*, `mv`). Since the semisolates is stored on disk, users are able to re-apply a different subset of effects or reorder semisolates differently—a capability that `hS` depends on [48].

7 Related Work

Containment and virtualization: There has been a significant amount of work on full isolation, including in containers [9, 54, 84, 87] and virtual machines [10, 12, 16, 53, 68]. These primitives create an isolated environment that is different from the host environment they execute in, completely avoiding sharing of any sort. Semisolates instead run a program in a simulacrum of the current environment—as if on the same environment, but with significantly lower risk—and allow for further and selective manipulation of its effects.

Software isolation and confinement: Earlier work on isolation and confinement [4, 36, 39, 69, 76, 78], focused on controlling and, if necessary, protecting against harmful component effects. These approaches offer structures at the operating system level, often not supporting unmodified Linux environments. In contrast, `try` leverages subsystems available in modern operating systems—requiring no modifications.

Tools such as `bubblewrap` [17] similarly rely on Linux kernel mechanisms to create isolated execution environments for unmodified programs. However, `bubblewrap` requires configuring the environment view available to the wrapped process ahead-of-execution, does not support layering, and either blocks effects during execution—potentially leaving the component at an inconsistent state—or reflects effects immediately to the host environment. In contrast, `try` requires no configuration (aside from optional path ignoring), supports layering unapplied effects across executions, and allows users to inspect and selectively apply effects *after* execution.

Other systems achieve confinement via system call interposition [14, 43]. For example, `MBOX` traces and interposes on system calls to inform the user of unintended or undesired effects. Such interposition meets only some of `try`'s requirements; it does not, for example, support stacking or further manipulation. Semisolates and `try` take a different approach, offering several more features—and compatibility across several modern environments.

Language-based wrapping and proxying: Semisolates bear resemblance to earlier research that attempts to control effects and capabilities using dynamic effect wrapping [5, 21, 51, 55, 57, 58]. In contrast to `try`, these approaches are not language-agnostic, as they are tightly integrated into a language and its runtime environment [5, 20, 21, 56], and often require developer effort through code modifications, or isolation policies [50, 57, 58, 61, 91]. Semisolates offer language-agnostic

effect control on unmodified programs.

Capabilities and sandboxing: Semisolates inherit ideas from early capability and sandboxing work [46, 47, 59, 60, 83]. Software fault isolation [97] rewrites object code to prevent execution reaching addresses outside a domain. Rather than completely restricting naming, `try` dynamically shadows names defined outside the compartment’s context—a technique isomorphic to a combination of capability revocation followed by attenuation; but contrary to earlier efforts, `try`’s shadowing works with completely unmodified binaries.

Filtering and access prevention: Another class of sandboxing tools is based on software fault isolation [97], including NaCl [81], WASM [33], and RLBox [63]. These systems focus on intraprocess memory-level isolation. Instead, `try` supports effect control (not isolation) outside the process—including effects such as file modifications.

Other systems control effects by preventing file accesses [77, 98, 100], terminating processes that access files outside an allowed set, or filtering dangerous or unnecessary system calls [22, 29, 42, 85]. These approaches prevent effects completely—possibly breaking the application if it needs to perform the effects to complete its execution.

Transactional filesystems: Earlier research on transactional filesystems [25, 79, 80, 88] has developed support for atomically committing or reverting changes to multiple files in a filesystem. In contrast to `try`, which allows calling programs to inspect and apply some of the effects—or further manipulate them at will.

8 Conclusion

Software systems consist of many components, written in many languages, and interacting with each other and the environment. This paper showcases the need for and feasibility of building a new abstraction, the semisolate, for controlling potentially undesired effects, maintaining full compatibility with real-world components, and incurring a performance overhead that is aligned with several practical applications.

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A LLM-Generated Scripts

This appendix lists the exact prompts used to generate the LLM-based benchmarks in §5.1, along with the scripts returned by ChatGPT.

crawl: Find & Touch

PROMPT

Write a simple Bash script that searches a directory (for example ./data) and runs a command on every file it finds. Use find with -exec and include comments explaining what the script does. The command should just touch each file.

GENERATED SCRIPT

```
1 directory="./data"
2 find "$directory" -type f -exec touch "{}" \;
```

fresh: Compress Files Larger Than 1 KB

PROMPT

Write a Bash script that finds all files larger than 1 KB in a directory (e.g., ./data) and compresses them using gzip. Use find with the -size filter and an -exec command. Include comments.

GENERATED SCRIPT

```
1 directory="./data"
2 find "$directory" -type f -size +1k \
3   -exec sh -c 'gzip "{}" \;
```

archive: Find All .txt Files

PROMPT

Give me a command to find all .txt files in the current directory and its subdirectories.

GENERATED SCRIPT

```
1 find . -name "*.txt"
```

logs: Extract Error Lines From Log

PROMPT

Give me a command to extract only ERROR, WARNING, or CRITICAL lines from a log file and save them to a new file. Make sure the command doesn't fail even if nothing is matched.

GENERATED SCRIPT

```
1 grep -E "ERROR|WARNING|CRITICAL" file.log \
2   > filtered_errors.log || true
```

order: Sort a File

PROMPT

Give me a command to sort the contents of book.txt and save the result to another file.

GENERATED SCRIPT

```
1 sort book.txt > sortedBook.txt
```

B Testimonials

This appendix includes testimonials from users who have tried `try` and shared their feedback on social media platforms. They offer a snapshot of real-world experiences and community reception of the tool. The feedback was primarily gathered from platforms such as personal blogs and Hacker News.

Looks nifty—basically it’s the “let me try that in a container first” except on your live system with no setup to get it going.

— @mikepurvis, Hacker News

This is a much needed software.

— @johnsbullings, Hacker News

Very interesting! This feels like something that should have always existed.

— @Benjamin Oakes, benjaminooakes.com

This is cool I probably will use this.

— @jagtstronaut, Hacker News

I love that their demo is to finally give me a dry run command for pip.

— @gdevenyi, Hacker News

The script is mounting an overlay filesystem for each root directory on the current system, then looking at what has been added as a new layer... Pure genius.

— @MichaelMoser123, Hacker News

I can see this being incredibly useful.

— river, lobste.rs

try is clever.

— Jim Fowler, x.com

I look forward to it helping me prevent programs polluting my laptop.

— bfiedlera, lobste.rs

This tool can bring a level of control that is typically only available in databases and VCSs, and make it a commodity.

— @klabb3, Hacker News

C Software Artifact

Abstract

The software artifact accompanying this paper consists of the `try` subsystem, its documentation, a test suite, and the scripts used to reproduce the evaluation in §5. It supports three goals: inspecting the implementation and its accompanying materials, exercising the system through its test suite, and reproducing the paper’s main evaluation results, including the summary across the five use cases and the microbenchmark breakdown.

Scope

The artifact covers the claims made by the paper’s implementation and evaluation sections. In particular, it includes: (1) the `try` subsystem and the semisolate abstraction described in §3 and §4; (2) the five use cases and supporting benchmarks from §2 and §5; and (3) the automation used to reproduce all key results in §5.

Contents

The artifact contains the following components:

- the `try` subsystem itself;
- documentation, including a top-level README, a manual page, and a short tutorial;
- a regression test suite covering `try`’s core functionality;
- the five evaluation workloads and their supporting utilities; and
- scripts for running the evaluation and generating all key result artifacts.

Hosting

The artifact is publicly available both as a GitHub repository and as a Zenodo archival snapshot. The GitHub version is hosted at <https://github.com/binpash/try/tree/osdi26-ae>, and the archival version is hosted at <https://zenodo.org/records/19444649>.