Rust Debugging Techniques

Robert O’Callahan
Pernosco

Context

- Fed up with state of debugging tools
- Created “rr” project at Mozilla
- Left Mozilla in 2016 to start **Pernosco**
- Pernosco: 113K lines of Rust

“Printf” Debugging

```
#[derive(Debug)]
struct Point { x: i32, y: i32 }

fn stuff(p: &Point) {
  println!("Point is: {:?}", p);
  …
```

dbg! Macro

```
let a = 2;
let b = dbg!(a*2) + 1;

[src/main.rs:2] a * 2 = 4
```

Logging

```
use log::debug;
fn stuff(p: &Point) {
  debug!("Point is: {:?}", p);
  …
```

```
RUST_LOG=debug target/debug/test_crate
DEBUG 2019-05-06T02:34:20Z: test_crate: hello
```

Don’t forget env_logger::init()!

Assertions

- Make your code easier to debug by catching mistakes early

```
assert!(remaining == 0);
assert!(remaining == 0,
        "{} remaining”, remaining);
assert_eq!(remaining, 0);
```

- Good documentation
- Makes tests more powerful

Release Assertions

- `assert!` runs in release builds
- `debug_assert!` runs only in debug builds
- Pernosco mostly uses `assert!`

Backtraces

```
RUST_BACKTRACE=1 target/debug/test_crate
thread 'main' panicked at 'assertion
failed: remaining == 0', src/main.rs:4:3
…
   6: test_crate::stuff
             at src/main.rs:4
   7: test_crate::main
             at src/main.rs:7
…
```

Levelling Up: gdb

- Lots of functionality, but non-discoverable

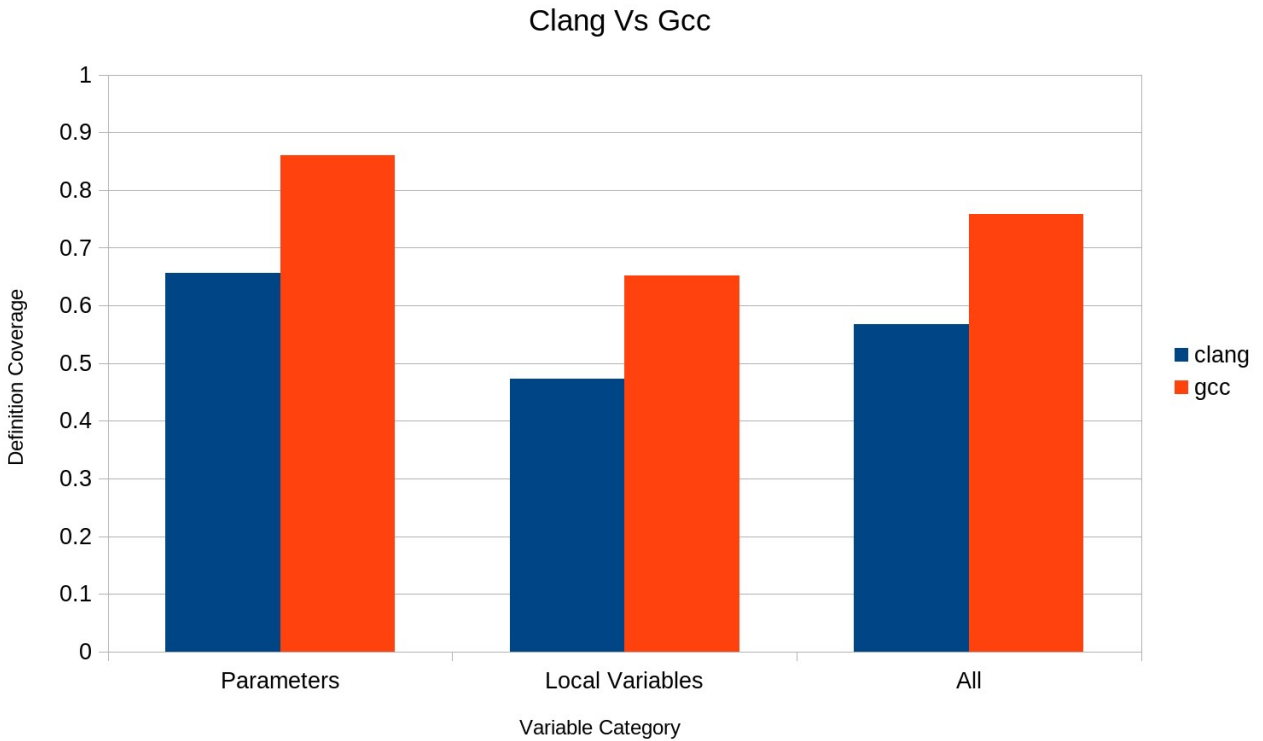
```
break   where       continue   print
run     commands    condition
watch -l        up    down  finish
next    step    nexti       stepi
disass      registers
info threads   thread
print user_function()
```

Rust gdb Tips

- Use gdb 8.2 or later for improved Rust support (prettyprinting enums)
- `break rust_panic_with_hook`
- `set lang c` when you get desperate

Debuginfo Quality

- LLVM’s DWARF debuginfo is poor in opt builds



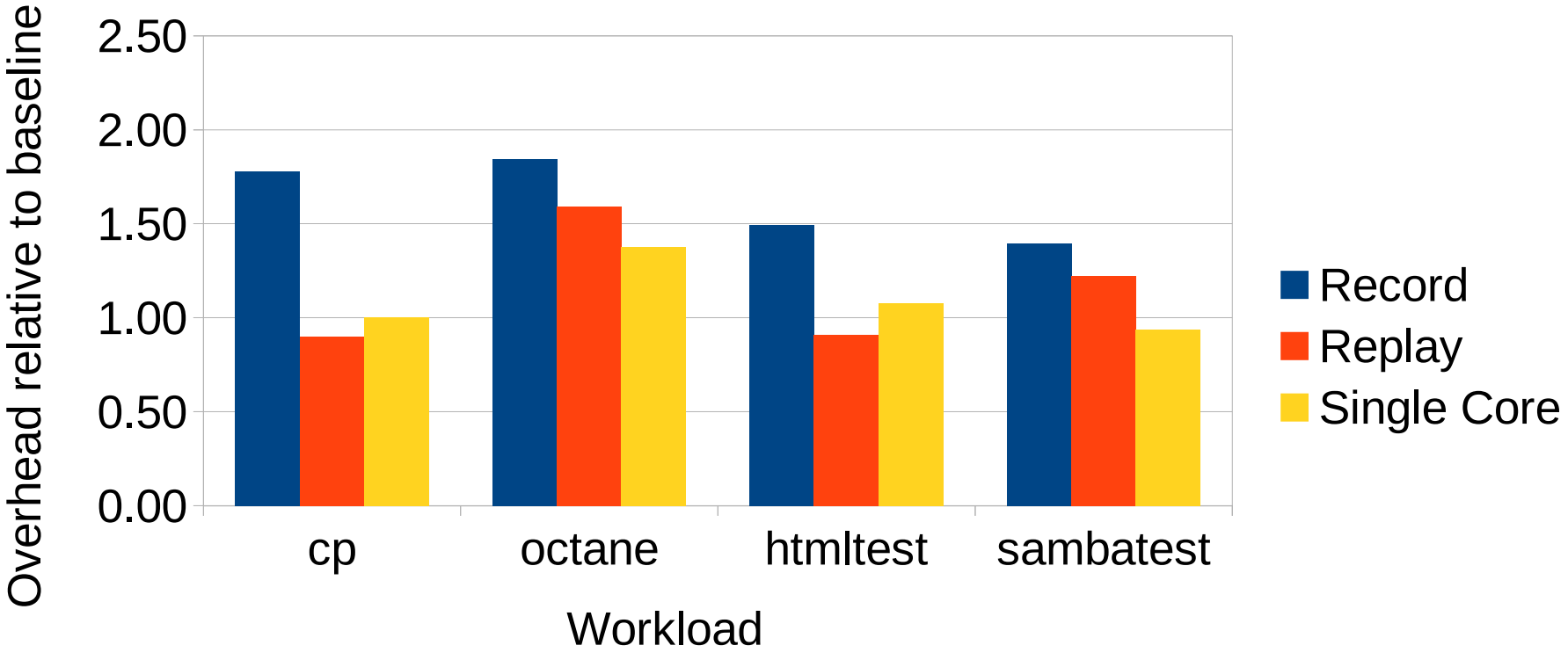
Limitations Of Traditional Debuggers

- Debugging follows effects back to causes
- Traditional debuggers let you execute forwards, stop, inspect program state
  - “execute forwards”: wrong direction
  - “stop”: can break your application
- Traditional debuggers require multiple runs
  - Don’t work with hard-to-reproduce bugs

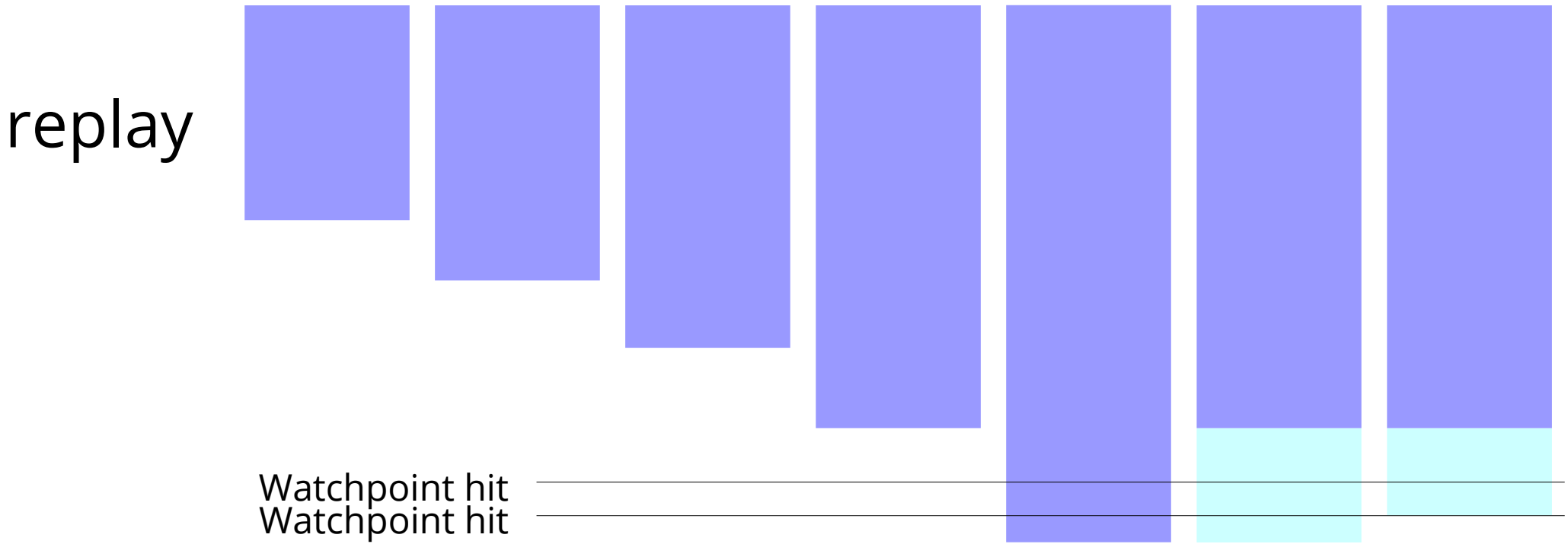
Record And Replay

- **Record** program execution without slowing it down much
- **Replay** recorded execution as many times as you want, with a debugger
- Simulate **reverse** execution

rr Overhead


Overhead relative to baseline
2.50
2.00
1.50
1.00
0.50
0.00
cp
octane
htmltest
sambatest
Workload
Record
Replay
Single Core

Reverse Execution



Debugging With Reverse Execution

```
(gdb) watch -l mRect.width
(gdb) reverse-continue
nsIFrame::SetRect
(this=0x2aaadd7dbeb0, aRect=...)
718         mRect = aRect;

(gdb) reverse-next
```

Chandler Carruth
@chandlerc1024

Follow

Debug on Linux at all? Stop and go get `rr` *RIGHT NOW*. Biggest improv. to debugging for me ever. H/T Justin Lebar.

Moves Vs Watchpoints

- Reverse execution with data watchpoints is an rr superpower
- Rust move-heavy code messes it up
  - Watchpoints stop at a move
  - Need to adjust address and continue :-(

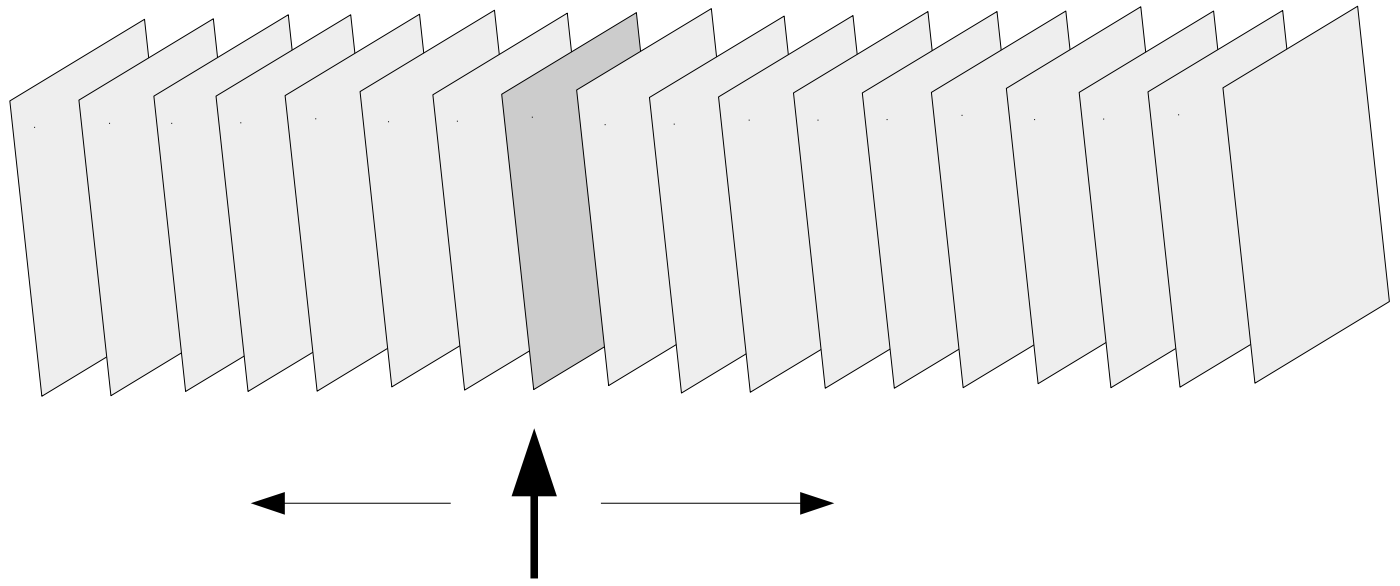
“Printf” Vs gdb For Rust

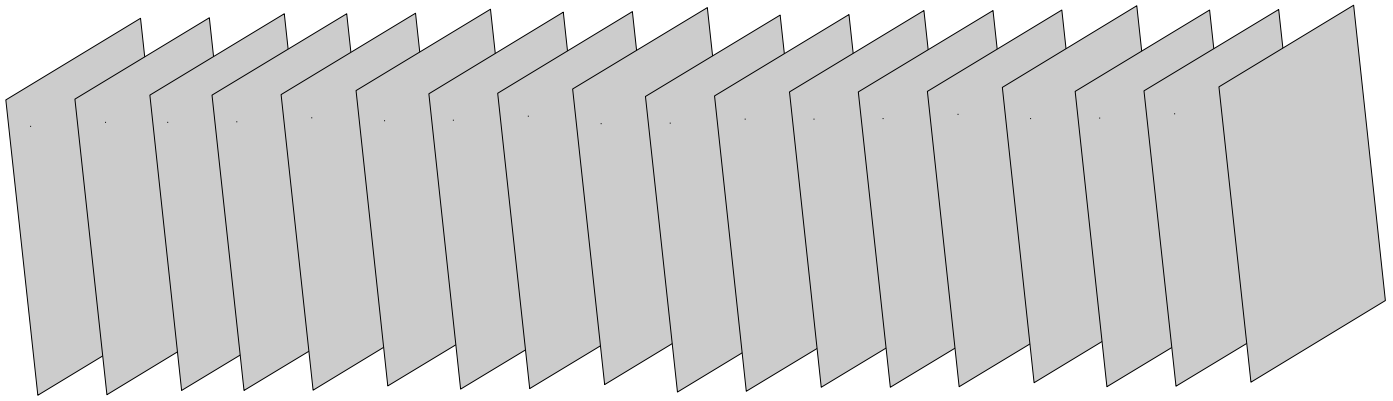
- Printf debugging:
  - #[derive(Debug)]
  - Works well with optimized builds
  - Slow Rust compile times
- Debugger:
  - Rust nonoptimized builds are very slow
  - Debugging async code (futures) is horrible

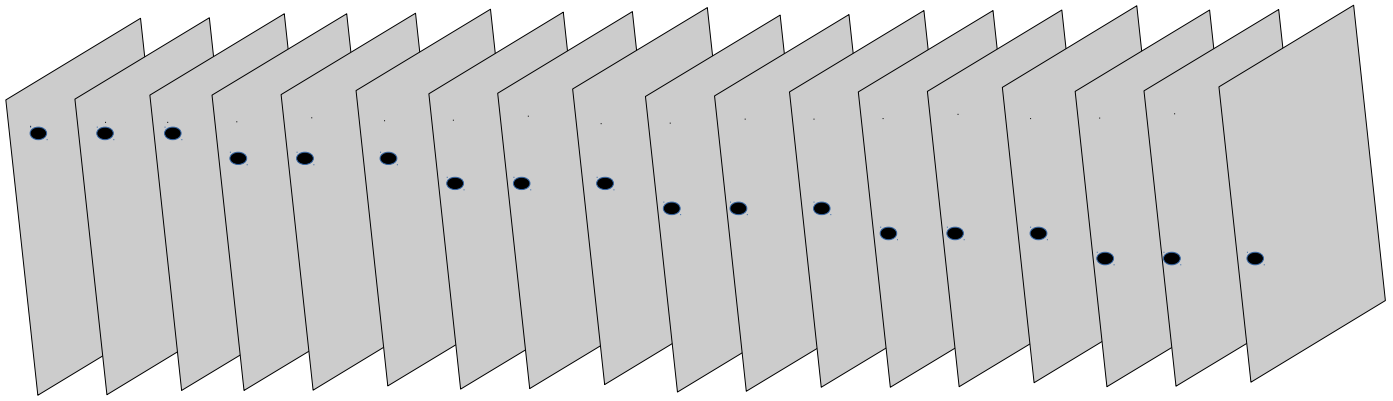
Pernosco

- Is record-and-replay with reverse execution the ultimate in debugging?

  NO!







“Point in time” debugging

→

Omniscient data analysis and visualization!

Omniscient Debugging

- Build an efficiently searchable database of all program states
  - E.g. all memory and register writes
    ODB, Chronomancer, Chronon…
- How to achieve acceptable overhead in real-world debugging situations?
- What is the ideal debugger UI when you drop “point in time” implementation constraints?

Demo

https://rr-project.org
https://github.com/mozilla/rr
https://pernos.co