Adventures in Porting Rust

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Rust for Morello

We have a port of the Rust compiler for Morello!

- Rust 1.56.0 (update to 1.72.1 coming)
- Target: Morello CHERI BSD
- Working compiler and standard library
- Builds real code (108k lines of benchmarks)

Website:

`https://www.cs.kent.ac.uk/people/staff/mjb211/rust/index.htm`

What I'll be talking about:

- Rust
- `usize`
- `const`
- Sizes
- Vtables
- `panic!()`

Why Rust?

Rust and CHERI fit together well

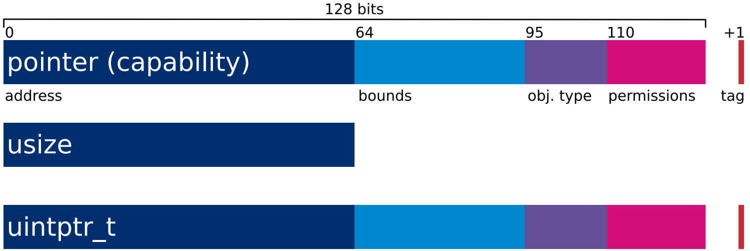
- Safety (especially memory safety) focused language
- Widely used
- CHERI protects `unsafe` sections (mostly)

```
extern "C" {
    fn iffy_c_library(data: *const u8);
}

fn main() {
    unsafe { iffy_c_library("Hello C\0".as_ptr()); }
}
```

The Problem: `usize`

`usize` is "The pointer-sized integer type." [1]

- Assumption: pointers are just an address
- Multiple solutions for CHERI
- Ours: `usize` is 64-bit
- It's Complicated



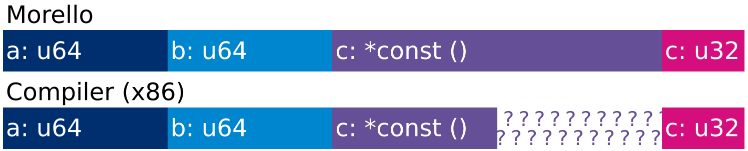
[1] Rust standard library documentation

const Expressions

const expressions happen at compile time

- Allows large subset of Rust
- Memory layout must match run time
- What about capability metadata?
- Our answer: leave uninitialised gaps

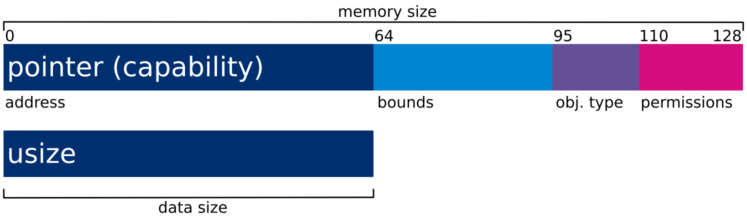
```
const POINTER: *const u8 = "a string".as_ptr();

struct Data { a: u64, b: 64, c: *const (), d: u32 }
const DATA: Data = Data{ a: 1, b: 2, c: POINTER, d: 3 };
```

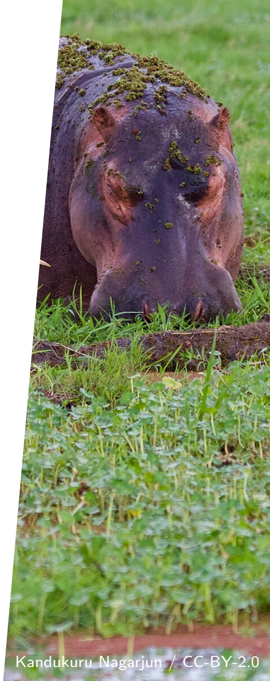


Data Size

Values in compiler need size information

- We now need size of data *and* size in memory
- `size` becomes `data_size` and `memory_size`
- Memory layout logic needs to record both sizes
- Propagate change through compiler (~230 files)
  `Scalar`, `ScalarInt`, `AllocRange`, `CodegenContext`, `TargetDataLayout`, `Layout`...



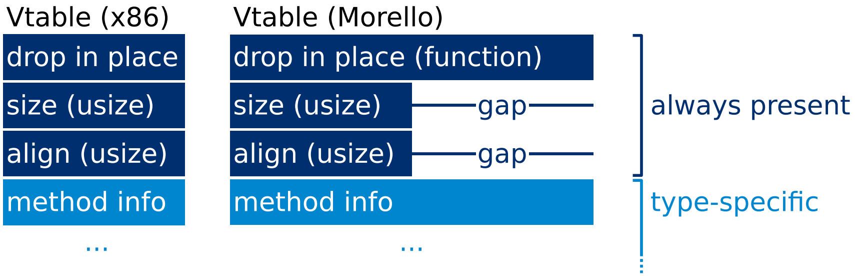


Vtables

References to types known only at run-time use vtables

```
trait DataTrait { fn reticulate(); }
fn dynamic_method_call(data: &dyn DataTrait) {
    data.reticulate();
}
```

- Stored as array of slots, some numbers, some pointers
- Assumes usize and pointers have same sizes
- Current solution: make every slot pointer sized

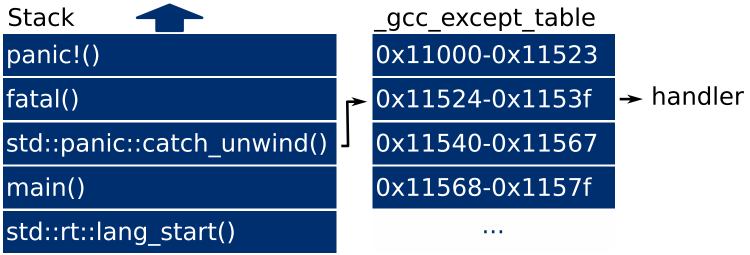


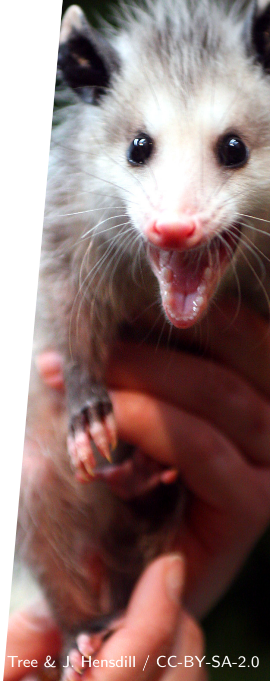
Don't (always) panic!()

panic!() emits error and terminates, but can be caught

```
fn fatal() { panic!("Oh no!") }
std::panic::catch_unwind(fatal);
```

- Borrows plumbing for exceptions
- Relies on reading tables of handlers
- Morello uses a custom encoding
- Extend Rust's reader to avoid messy crashes





Questions, Perhaps Even Answers...

That's (some of) how you port Rust to Morello!

- Rust 1.56.0 compiler (1.72.1 on the way)
- Targets CHERI BSD on Morello
- Includes standard libraries

Compiler source, binaries:

`https://www.cs.kent.ac.uk/people/staff/mjb211/rust/index.htm`

ECOOP paper:

`https://drops.dagstuhl.de/entities/document/10.4230/LIPIcs.ECOOP.2023.39`