RUST

INTRO FOR C++ PROGRAMMERS

Created by Kai / @_cibo_ and Ben / @predatorhat

```rust
fn main() {
    println!("Hello, there!");
}
```

rust-lang.org

play.rust-lang.org

- No garbage collector
- No big runtime
- Automatic memory management
- Zero-cost abstractions

SYNTAX

- Imperative
- C/C++-like: curly braces and semicolons as function and statement delimiter.
- Freeform: indentation isn't significant

C++	Rust
auto x = 42;	let x = 42;
std::unique_ptr<T>	Box<T>
std::shared_ptr<T>	Rc<T> and Arc<T>
Destructors	trait Drop
__asm	asm! macro

SELLING POINT?

Quite similar to C++. So why do we need another language?

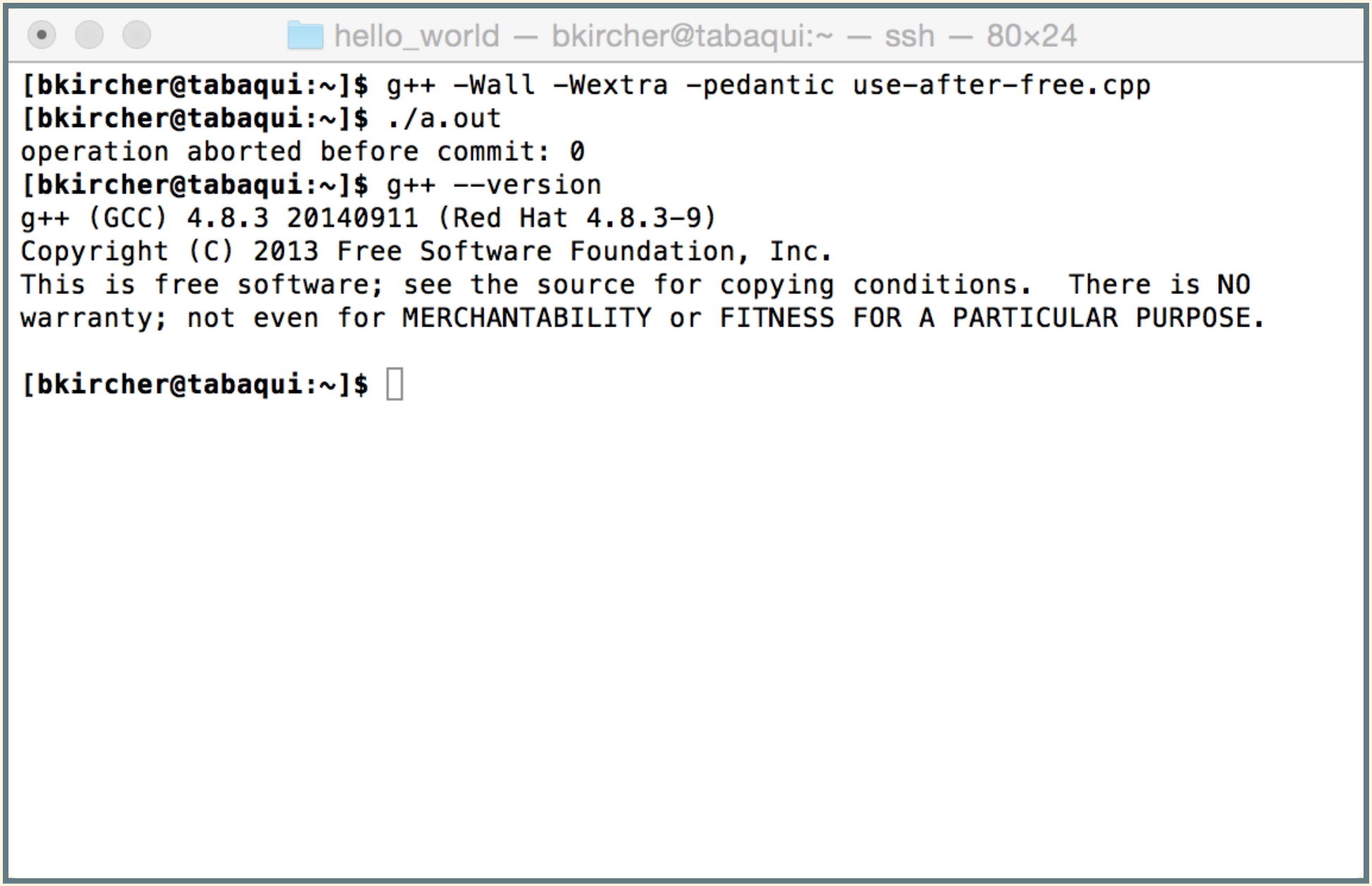
SELLING POINT?

Rust's type system!

```c
void logError(const char* msg, int* ints) {
    fprintf(stderr, "%s: %i\n", msg, ints[0]);
}

int main() {
    int* ptr = (int*)malloc (SIZE);
    // ...
    if (err) {
        abrt = 1;
        free(ptr);
    }
    // ...
    if (abrt) {
        logError("operation aborted before commit", ptr);
    }
}
```

CWE-416: Use After Free


hello_world — bkircher@tabaqui:~ — ssh — 80×24
[bkircher@tabaqui:~]$ g++ -Wall -Wextra -pedantic use-after-free.cpp
[bkircher@tabaqui:~]$ ./a.out
operation aborted before commit: 0
[bkircher@tabaqui:~]$ g++ --version
g++ (GCC) 4.8.3 20140911 (Red Hat 4.8.3-9)
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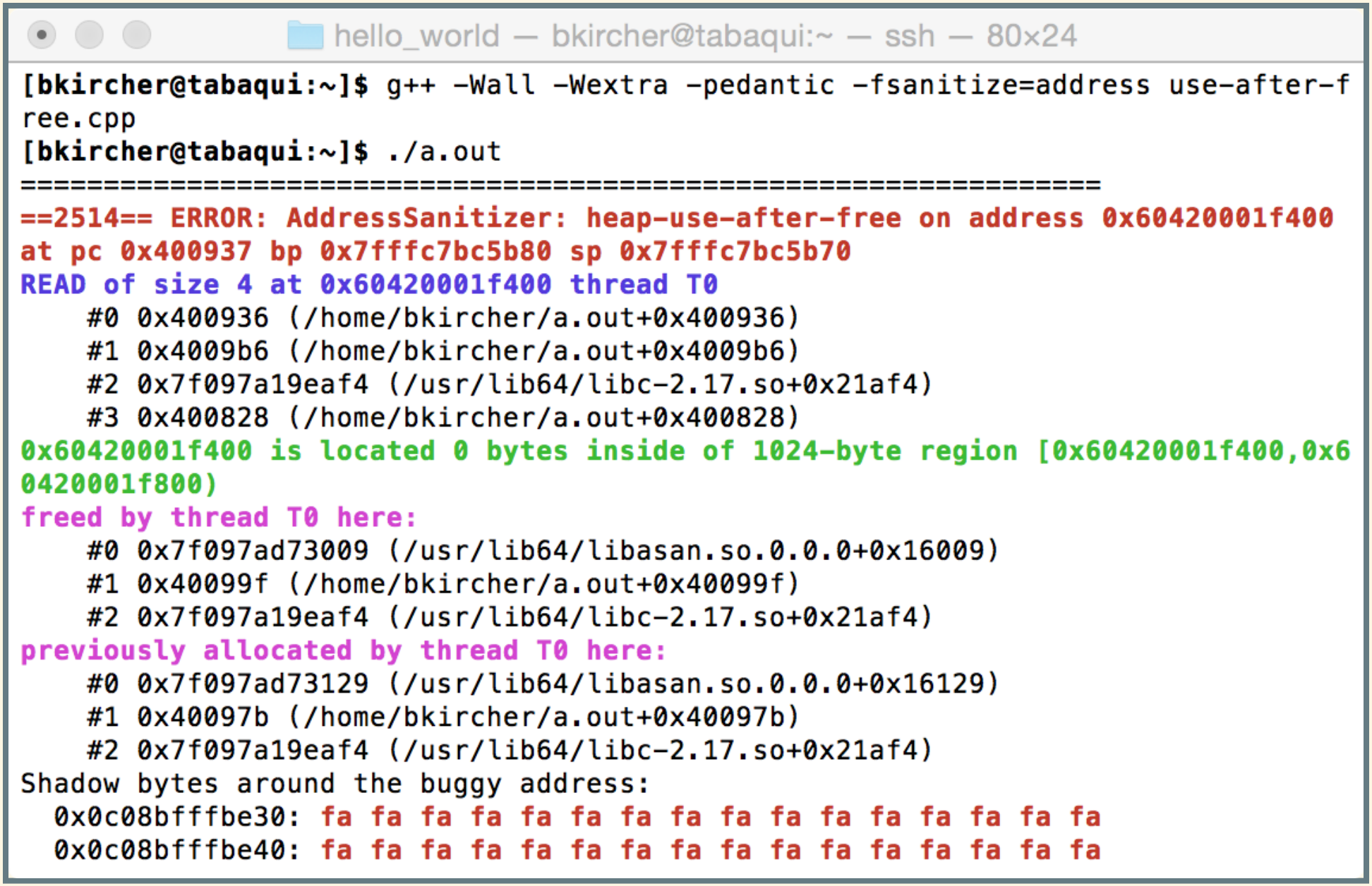
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
[bkircher@tabaqui:~]$


hello_world — bkircher@tabaqui:~ — ssh — 80×24
[bkircher@tabaqui:~]$ g++ -Wall -Wextra -pedantic -fsanitize=address use-after-free.cpp
[bkircher@tabaqui:~]$ ./a.out
==2514== ERROR: AddressSanitizer: heap-use-after-free on address 0x60420001f400 at pc 0x400937 bp 0x7fffc7bc5b80 sp 0x7fffc7bc5b70
READ of size 4 at 0x60420001f400 thread T0
#0 0x400936 (/home/bkircher/a.out+0x400936)
#1 0x4009b6 (/home/bkircher/a.out+0x4009b6)
#2 0x7f097a19eaf4 (/usr/lib64/libc-2.17.so+0x21af4)
#3 0x400828 (/home/bkircher/a.out+0x400828)
0x60420001f400 is located 0 bytes inside of 1024-byte region [0x60420001f400,0x60420001f800)
freed by thread T0 here:
#0 0x7f097ad73009 (/usr/lib64/libasan.so.0.0.0+0x16009)
#1 0x40099f (/home/bkircher/a.out+0x40099f)
#2 0x7f097a19eaf4 (/usr/lib64/libc-2.17.so+0x21af4)
previously allocated by thread T0 here:
#0 0x7f097ad73129 (/usr/lib64/libasan.so.0.0.0+0x16129)
#1 0x40097b (/home/bkircher/a.out+0x40097b)
#2 0x7f097a19eaf4 (/usr/lib64/libc-2.17.so+0x21af4)
Shadow bytes around the buggy address:
0x0c08bfffbe30: fa fa fa fa fa fa fa fa fa fa fa fa fa fa fa fa
0x0c08bfffbe40: fa fa fa fa fa fa fa fa fa fa fa fa fa fa fa fa

To catch this in C or C++ you need

- Something like ASAN and/or Valgrind's Memcheck
- Good test coverage
- And you need to run those tests
- If code is in one TU: static code analysis *might* help

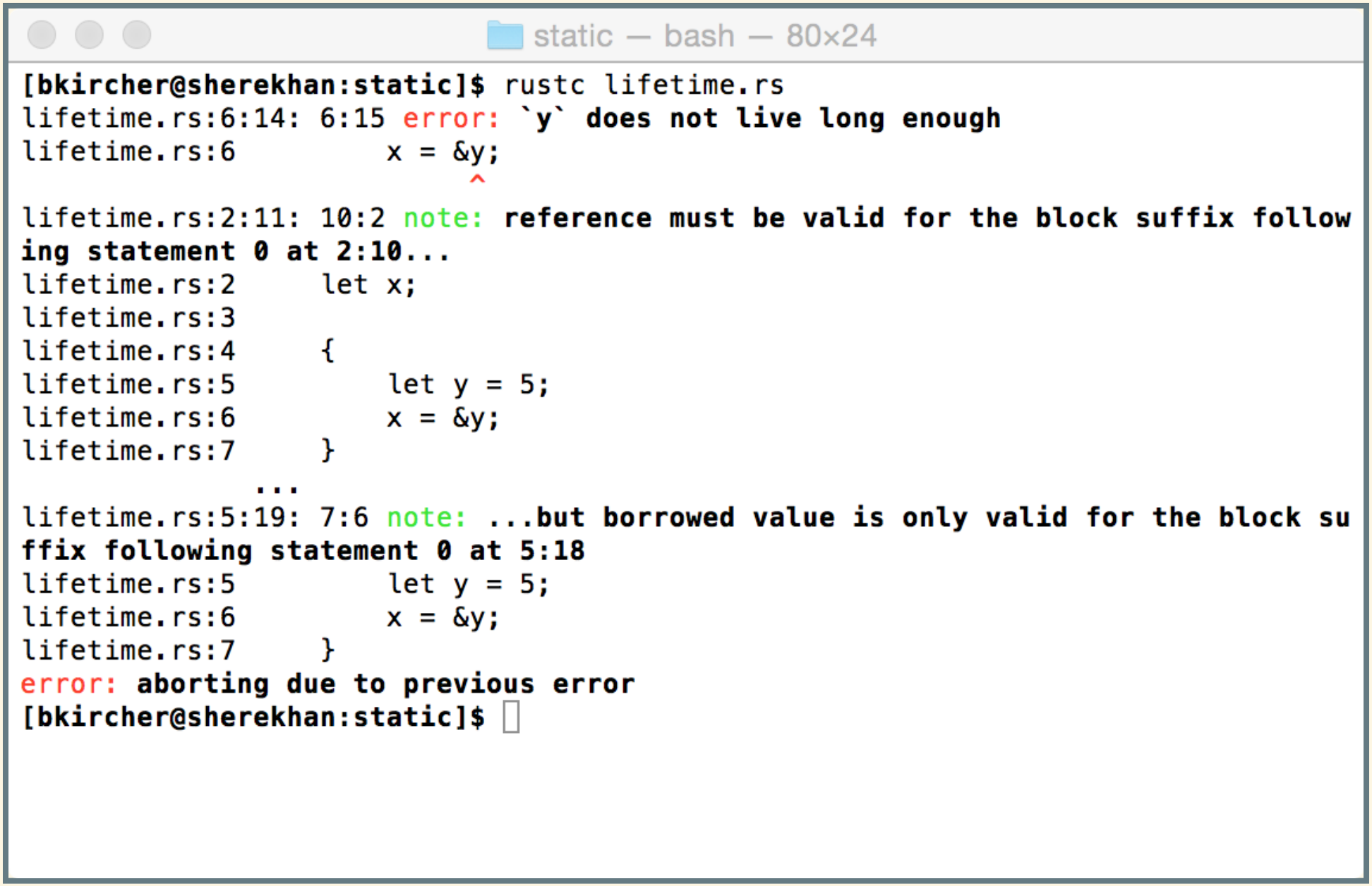
In Rust, lifetime is part of an object's type

```
fn main() {
    let x;

    {
        let y = 5;
        x = &y;
    }

    println!("x's value is {}", x);
}
```

And thus, checked at compile time



OWNERSHIP

Move by default: variables are *moved* to new locations, preventing previous locations from using it.

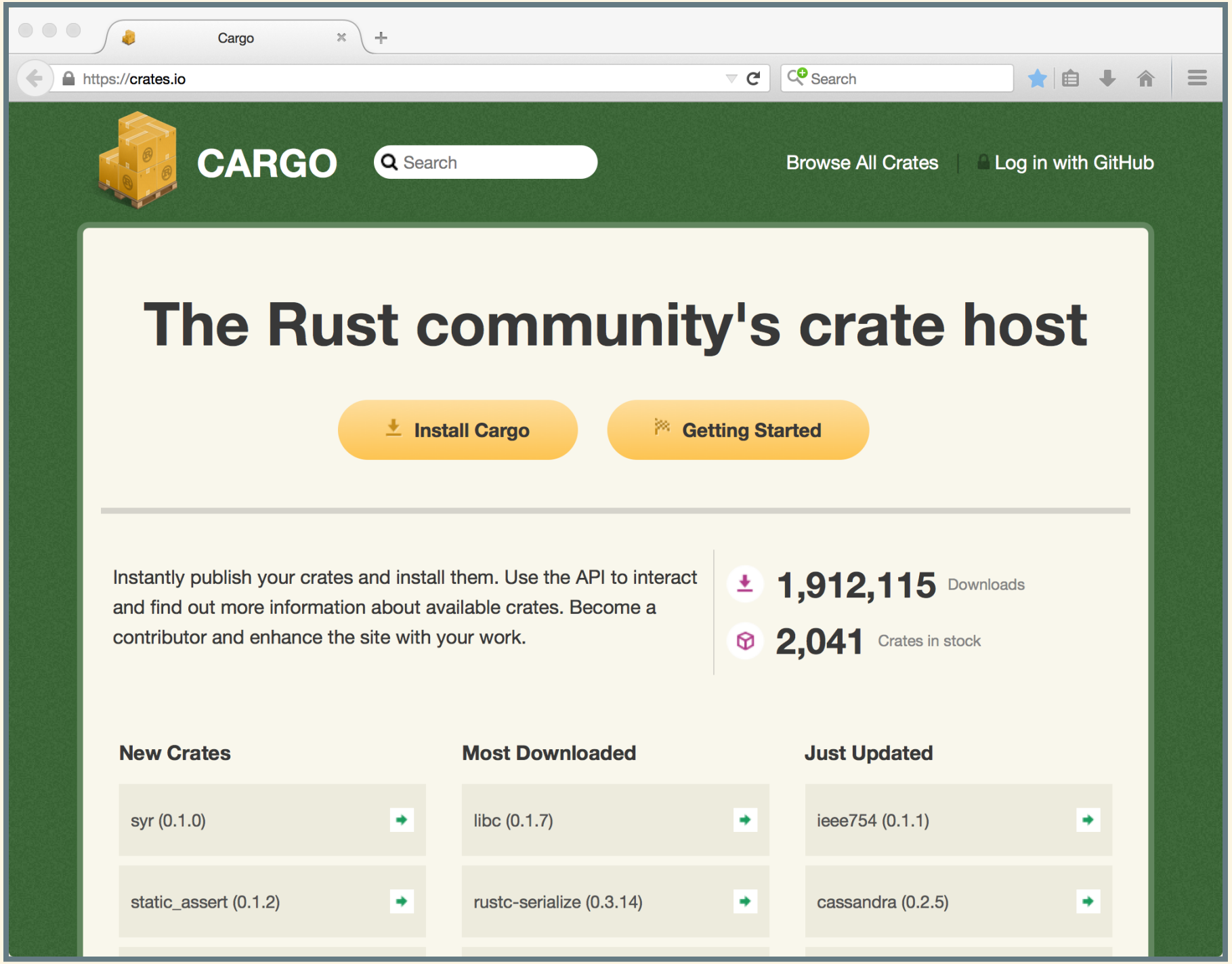
There is only one owner of data!

WHO IS USING RUST?

- rustc
- Mozilla Servo browser engine
- Skylight, a profiler for Rails apps

LIBRARIES?

https://crates.io/


Cargo
https://crates.io
Search
CARGO
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Browse All Crates
Log in with GitHub
The Rust community's crate host
Install Cargo
Getting Started
Instantly publish your crates and install them. Use the API to interact and find out more information about available crates. Become a contributor and enhance the site with your work.
1,912,115 Downloads
2,041 Crates in stock
New Crates
syr (0.1.0)
static_assert (0.1.2)
Most Downloaded
libc (0.1.7)
rustc-serialize (0.3.14)
Just Updated
ieee754 (0.1.1)
cassandra (0.2.5)

CRATES & MODULES

A CRATE IS THE RUST EQUIVALENT TO A C LIBRARY OR BINARY

```
rustc hello_world.rs
./hello_world
Hello, World!
```

A SINGLE SOURCE FILE DEFINES ONE OR MORE MODULES.

foo.rs:

```
mod foo {
  fn hello_world() {
    println!("Hello, World!");
  }

  mod bar {
    fn goodbye_world() {
      println!("Goodbye!");
    }
  }
}
```

```
foo::bar::goodbye_world();
```

A SOURCE FILE CAN REFERENCE OTHER MODULES

main.rs:

```
mod foo;

fn main() {
  foo::hello_world();
}
```

```
rustc main.rs
```

Compiles main.rs and foo.rs into main executable.

A SOURCE FILE CAN REFERENCE EXTERNAL MODULES

```
rustc --crate-type dylib foo.rs
```

main.rs:

```
extern crate foo;

fn main() {
  foo::hello_world();
}
```

```
rustc main.rs
```

Compiles main.rs and links foo at run time.

CARGO

```
cargo new --bin program_name
```

```
[package]
name = "program_name"
version = "0.0.1"
authors = ["Kai Michaelis <kai.michaelis@rub.de>"]

[dependencies]
num = "~0.0.4"
slow_primes = "~0.1.4"
```

Downloads all dependencies and builds everything

```
cargo build
```

FFI

Calling C from Rust and vice versa

FFI

Call Rust code directly from C or C++

```
#[no_mangle]
pub extern fn hello_rust() -> *const u8 {
    "Hello, world!\0".as_ptr()
}
```

FFI

Call C code from Rust also pretty easy

```
int sqlite3_open(
    const char *filename,   /* Database filename (UTF-8) */
    sqlite3 **ppDb          /* OUT: SQLite db handle */
);
```

translates basically to

```
extern crate libc;
use libc::c_int,c_char;

#[link(name = "sqlite3")]
extern {
    pub fn sqlite3_open(filename: *const c_char,
                        ppDb: *mut *mut sqlite3) -> c_int;
}
```

FFI

You wouldn't do this yourself all the way: there is bindgen

FFI

And of course, you wouldn't do this with sqlite3 because there is already crates.io/crates/rusqlite

PATTERN MATCHING & DECONSTRUCTION

TYPES IN RUST

Rust	C++
`bool`	`bool`
`u8, u16, u32, u64`	`uint8_t, uint16_t, uint32_t, uint64_t`
`i8, i16, i32, i64`	`int8_t, int16_t, int32_t, int64_t`
`usize, isize`	`uintptr_t, intptr_t`
`f32, f64`	`float, double`
`char`	`32 bit Unicode code point`

TYPES IN RUST (CONT.)

Rust	C++
`str`	`std::string, UTF-8 encoded`
`(A, B, ...)`	`std::tuple<A,B,...>`
`[T; N]`	`std::array<T,N>`
`&[T]`	`Pair of iterators`
`type A = B`	`using A = B`
`struct A { ... }`	`class A { ... }`
`enum A { ... }`	`boost::variant`

DECONSTRUCTION

```
struct Employee {
    name: String,
    age: u8,
    department: String
}
```

```
let e1 = Employee {
    name:       "Kai Michaelis".to_string(),
    age:        29,
    department: "Engineering".to_string()
};

let Employee{ name: n, ..} = e1;

// Prints "Hello, I'm Kai Michaelis"
println!("Hello, I'm {}",n);
```

```
let e1 = Employee {
    name:       "Kai Michaelis".to_string(),
    age:        29,
    department: "Engineering".to_string()
};

if let Employee{ age: 67, ..} = e1 {
    println!("Time to retire!");
} else {
    println!("You still got {} years to go",67 - e1.age);
}
```

ENUMERATIONS

```
#[derive(PartialEq)]
enum Fruit {
    Apple = 1,
    Banana = 2,
    Kiwi,
    Pineapple
}
```

```
fn say_it(fruit: Fruit) {
    if fruit == Fruit::Apple {
        println!("Apple");
    } else if fruit == Fruit::Banana {
        println!("Banana");
    } else if fruit == Fruit::Kiwi {
        println!("Kiwi");
    } else if fruit == Fruit::Pineapple {
        println!("Pineapple");
    }
}
```

```
enum NumberOrText {
    Number(i32),
    Text(String)
}
```

```
fn print_number_or_text(nt: NumberOrText) {
    match nt {
        NumberOrText::Number(i) => println!("Number: {}",i),
        NumberOrText::Text(t) => println!("Text: {}",t)
    }
}
```

```
let a: NumberOrText = Number(42);
let b: NumberOrText = Text("Hello, World".to_string());

// Prints "Number: 42"
print_number_or_text(a);

// Prints "Text: Hello, World"
print_number_or_text(b);
```

SIMPLE TREE WALKING

```
use std::boxed::Box;
use std::ops::Deref;

enum Tree {
    Leaf(char),
    Node(Box<Tree>,Box<Tree>)
}

fn depth_first_search(root: &Tree) {
    match root {
        &Tree::Leaf(s) => println!("{}",s),
        &Tree::Node(ref left,ref right) => {
            depth_first_search(left.deref());
            depth_first_search(right.deref())
        }
    }
}
```

SIMPLE TREE WALKING (CONT.)

```
fn main() {
    let tree =
      Box::new(Tree::Node(
          Box::new(Tree::Node(
              Box::new(Tree::Leaf('H')),
              Box::new(Tree::Node(
                  Box::new(Tree::Leaf('e')),
                  Box::new(Tree::Leaf('l')))))),
            Box::new(Tree::Node(
                Box::new(Tree::Node(
                    Box::new(Tree::Leaf('l')),
                    Box::new(Tree::Leaf('o'))))),
                Box::new(Tree::Leaf('!'))))));

    // Prints "Hello!"
    depth_first_search(&tree);
}
```

SMALL PEEK INTO ERROR HANDLING

panic! unwinds the thread

```
fn guess(n: i32) -> bool {
    if n < 1 || n > 10 {
        panic!("Invalid number: {}", n);
    }
    n == 5
}

fn main() {
    guess(11);
}
```

std::option::Option

```
enum Option<T> {
    None,
    Some(T),
}
```

Option<T>

```
fn find(haystack: &str, needle: char) -> Option<usize> {
    for (offset, c) in haystack.char_indices() {
        if c == needle {
            return Some(offset);
        }
    }
    None
}

fn main() {
    let filename = "foobar.txt";
    match find(filename, '.') {
        Some(i) => println!("Filename extension: {}", &filename[i+1..]),
        None => println!("No extension found!"),
    }
}
```

THOUGHTS ON ERROR HANDLING IN RUST

Somewhat mixed...

1. Way better than arbitrary return values
2. Seems harder to use than exceptions
3. Anyone?