
Systems programming for all

What Rust has to offer

Strong safety guarantees…

No seg-faults, no data-races, expressive type system.

…without compromising on performance.

No garbage collector, no runtime.

Goal:

Confident, productive systems programming

Safety =

Eat your spinach!

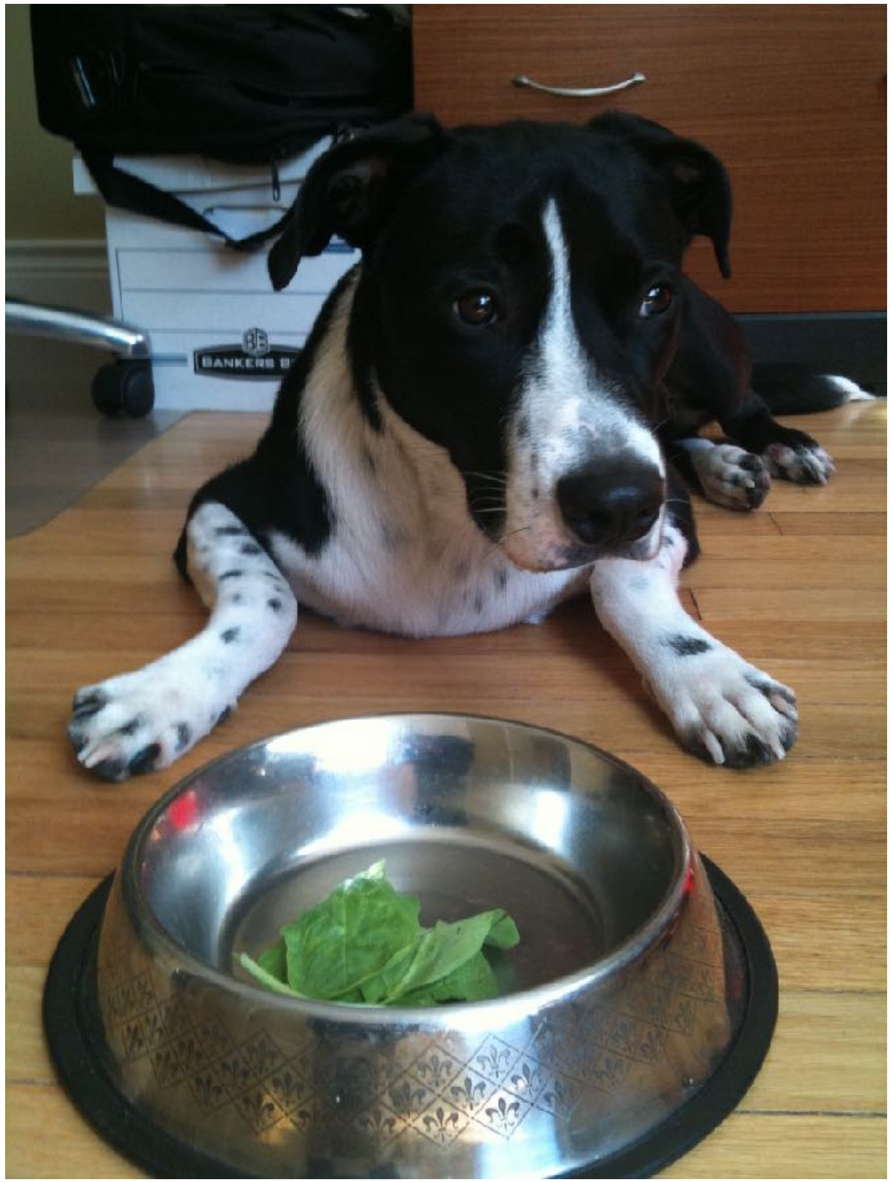

Photo credit: Sanjoy Ghosh
https://www.flickr.com/photos/sanjoy/4016632253/

Safety = Eat your spinach!

Photo credit: Salim Virji
https://www.flickr.com/photos/salim/8594532469/

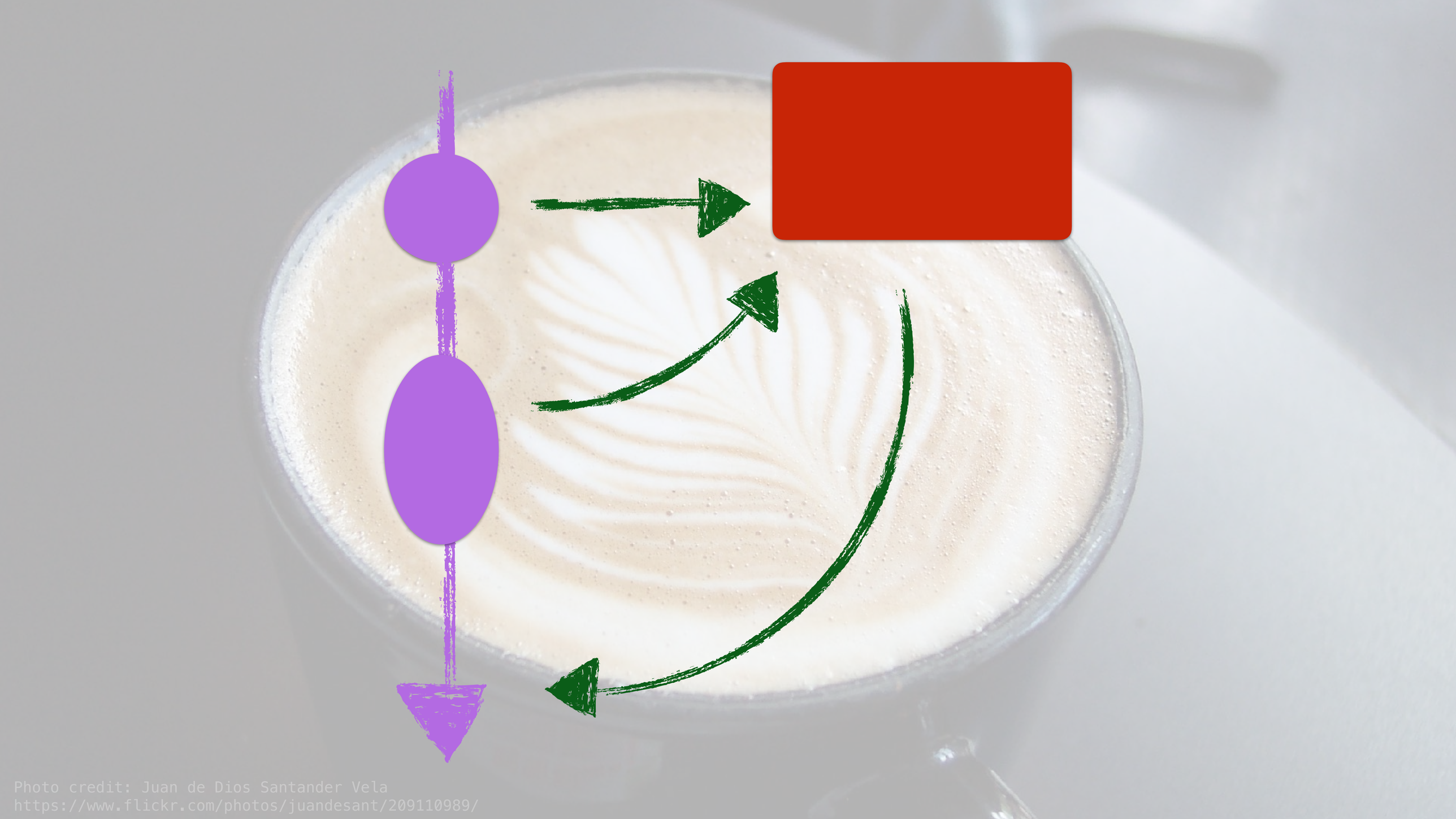

Photo credit: Juan de Dios Santander Vela
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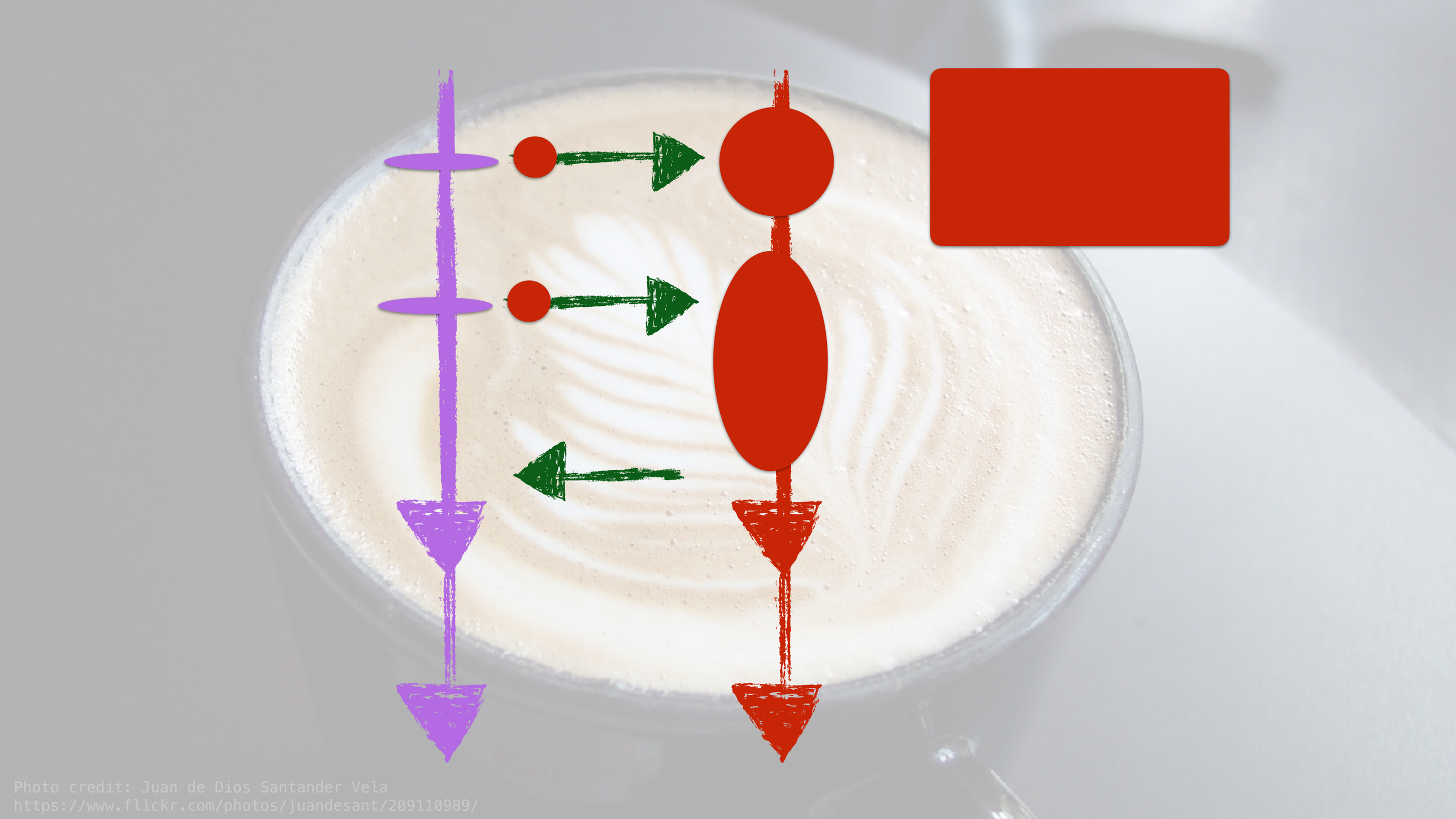

Photo credit: Juan de Dios Santander Vela
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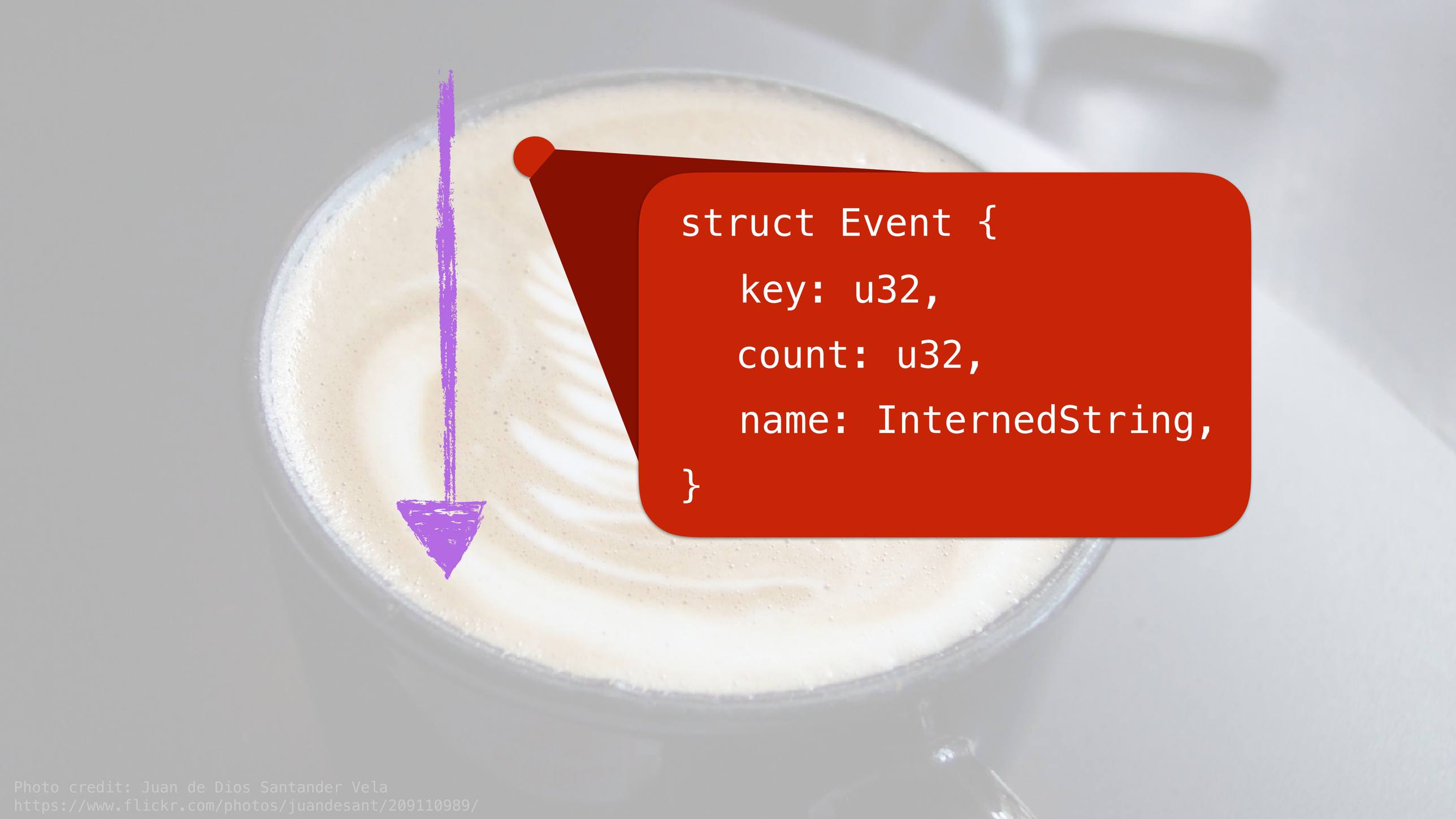
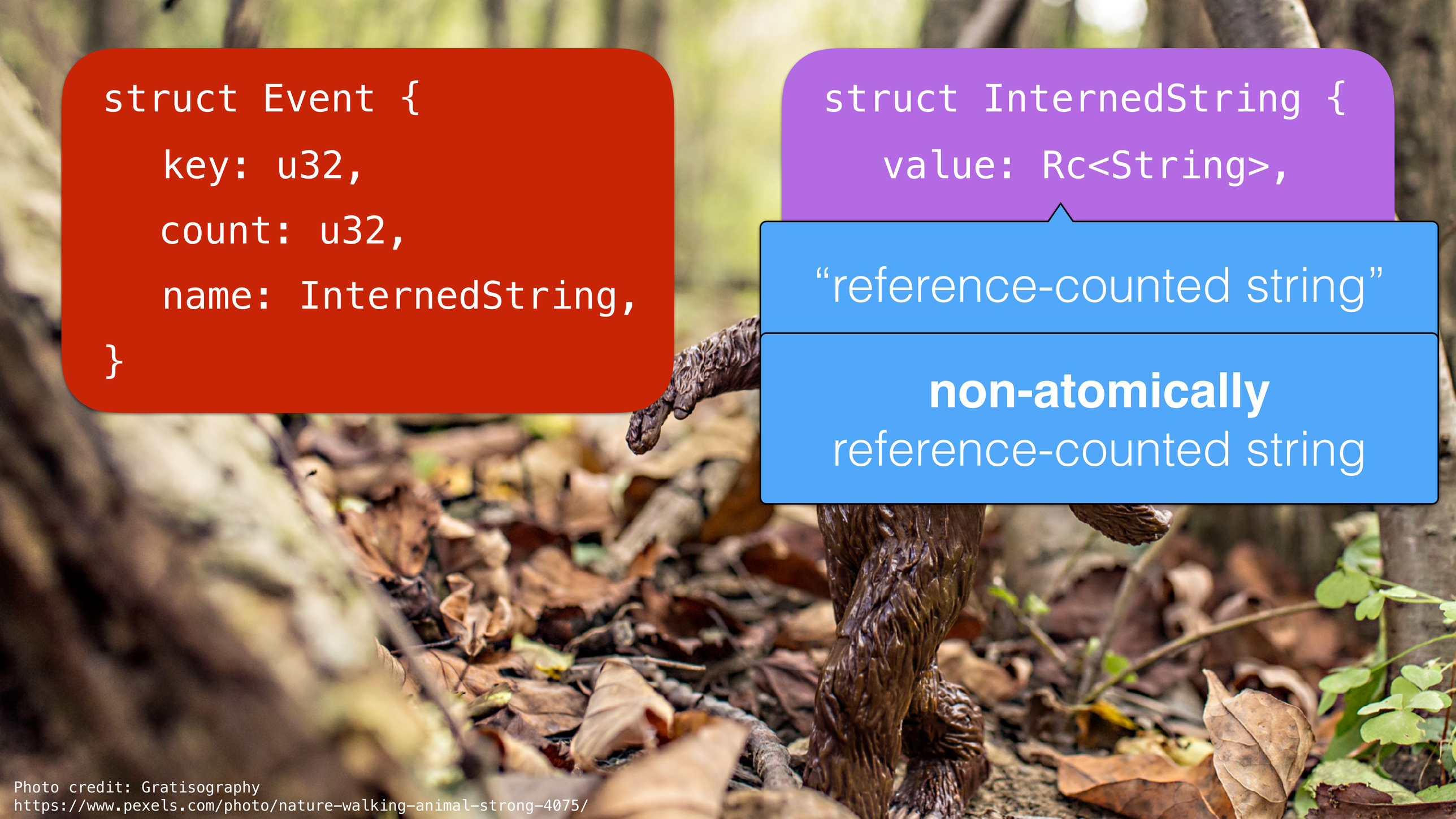
six months later…



```
struct Event {
    key: u32,
    count: u32,
    name: InternedString,
}
```

Photo credit: Juan de Dios Santander Vela
https://www.flickr.com/photos/juandesant/209110989/



```
struct Event {
    key: u32,
    count: u32,
    name: InternedString,
}
```

```
struct InternedString {
    value: Rc<String>,
```

“reference-counted string”

non-atomically
reference-counted string

Photo credit: Gratisography
https://www.pexels.com/photo/nature-walking-animal-strong-4075/

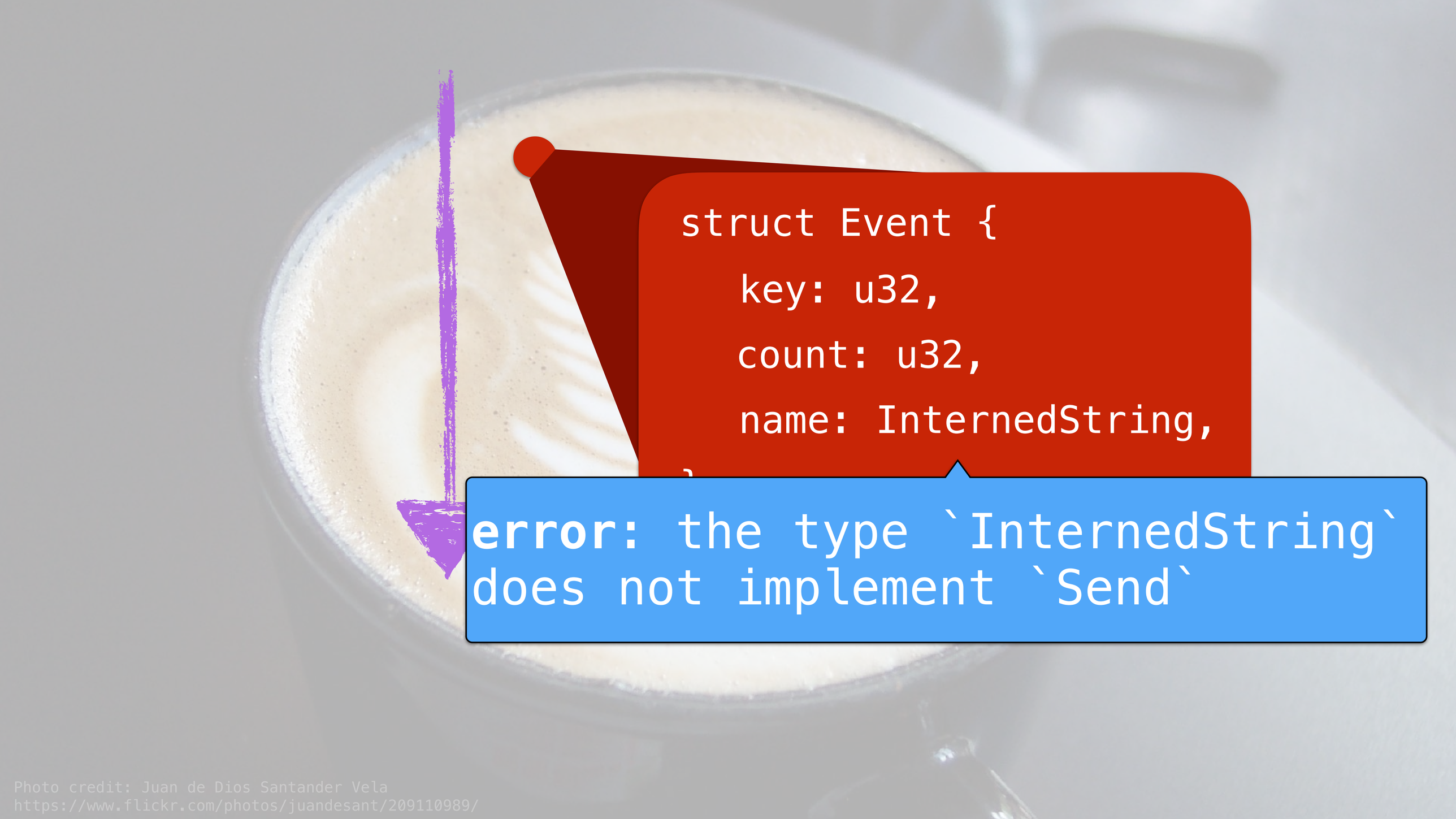


Photo credit: Juan de Dios Santander Vela
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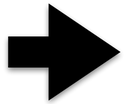
“Zero cost” abstraction



```
vec1.iter()                    // vec1’s elements
    .zip(vec2.iter())          // paired with vec2’s
    .map(|(i, j)| i * j)       // multiplied
    .sum()                     // and summed
```

```
.LBB0_8:
  movdqu (%rdi,%rbx,4), %xmm1
  movdqu (%rdx,%rbx,4), %xmm2
  pshufd $245, %xmm2, %xmm3
  pmuludq  %xmm1, %xmm2
  pshufd $232, %xmm2, %xmm2
  pshufd $245, %xmm1, %xmm1
  pmuludq  %xmm3, %xmm1
  pshufd $232, %xmm1, %xmm1
  punpckldq %xmm1, %xmm2
  paddd%xmm2, %xmm0
  addq $4, %rbx
  incq %rax
  jne.LBB0_8
```

Parallel execution

```
vec1.par_iter()
    .zip(vec2.par_iter())
    .map(|(i, j)| i * j)
    .sum()
```

Multicore (work stealing)

+ SIMD

+ Guaranteed thread safety

The Rust community's crate registry

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.

234,806,125 Downloads

11,846 Crates in stock

New Crates

- etcommon-block-core (0.1.0)
- dsdl_parser (0.0.1)
- tokenlock (0.1.1)

Most Downloaded

- libc (0.2.32)
- bitflags (1.0.0)
- winapi (0.2.8)

Just Updated

- sputnikvm (0.7.8)
- rusty-blockparser (0.6.1)
- rustracing_jaeger (0.1.2)

Rust the language

Memory safety
Traits
Parallelism
Unsafe

Rust the community

Rust in Firefox
Community processes

Memory safety

Photo credit: Amelia Wells
https://www.flickr.com/photos/speculummundi/6424242877/

Zero-cost abstractions

+

Memory safety & data-race freedom

=

Confident, productive systems programming

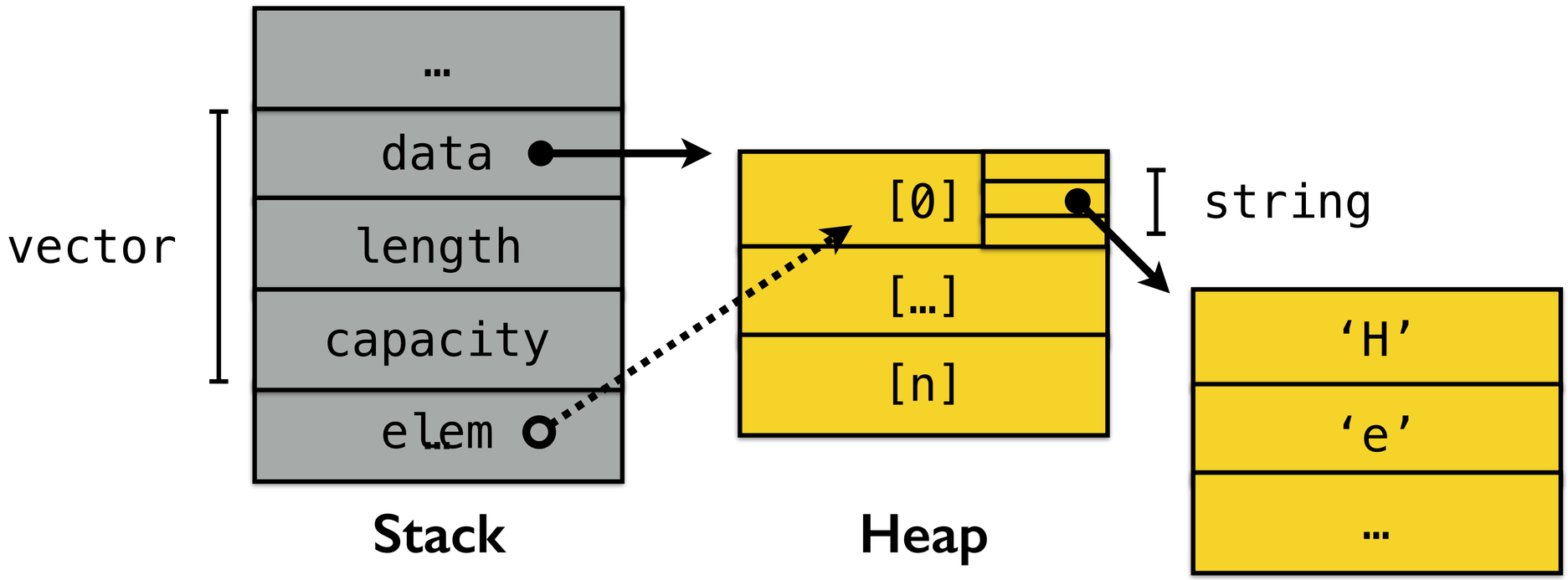
Zero-cost abstractions

```
void example() {
  vector<string> vector;
  …
  auto& elem = vector[0];
  …
}
```

Stack and inline layout.

Lightweight references

Deterministic destruction

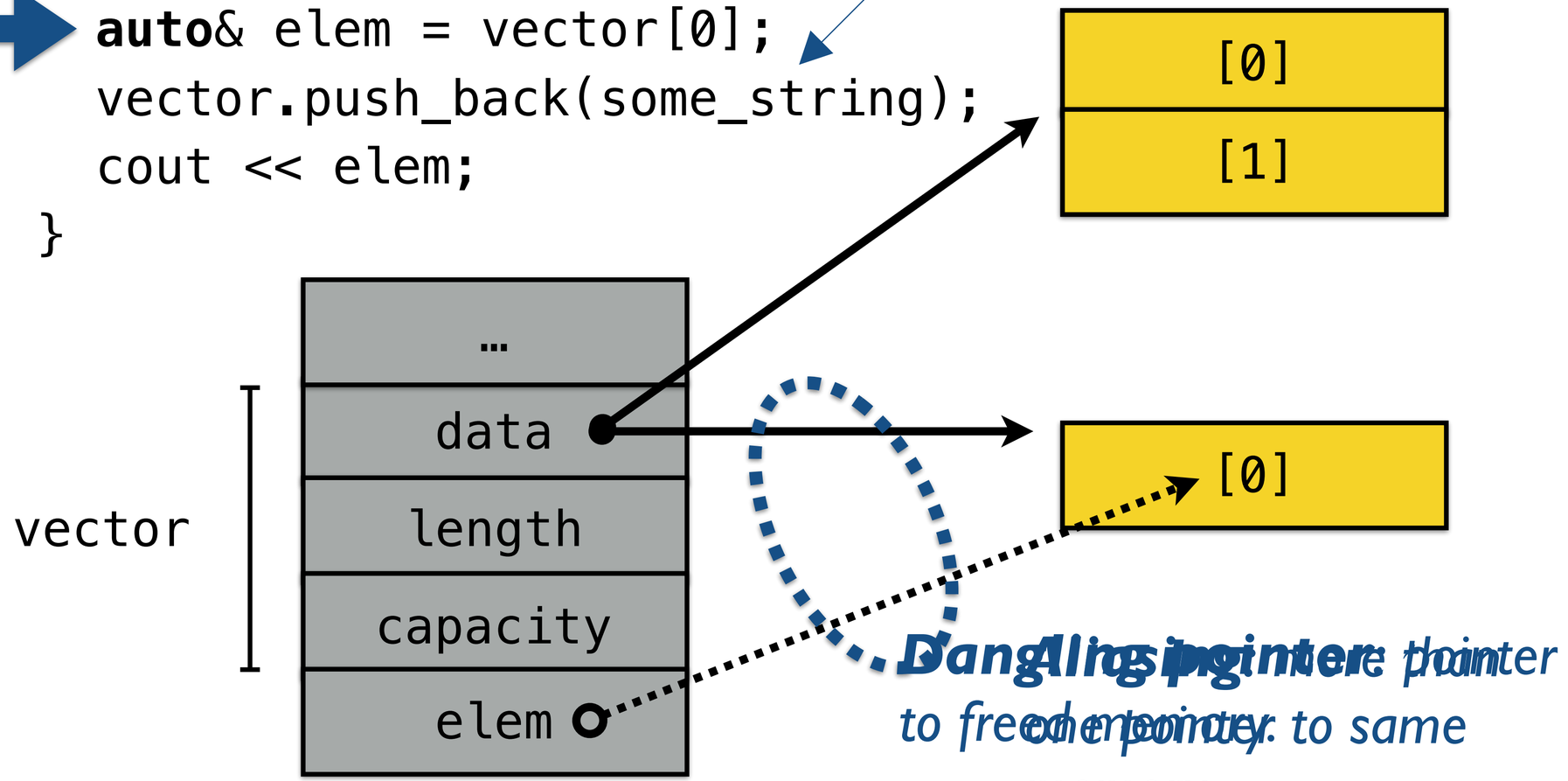


C++

Memory safety

```
void example() {
  vector<string> vector;
  …
  auto& elem = vector[0];
  vector.push_back(some_string);
  cout << elem;
}
```

Mutating the vector freed old contents.



Dangling pointer: *pointer to freed memory.*

Aliasing: *two pointer to same memory.*

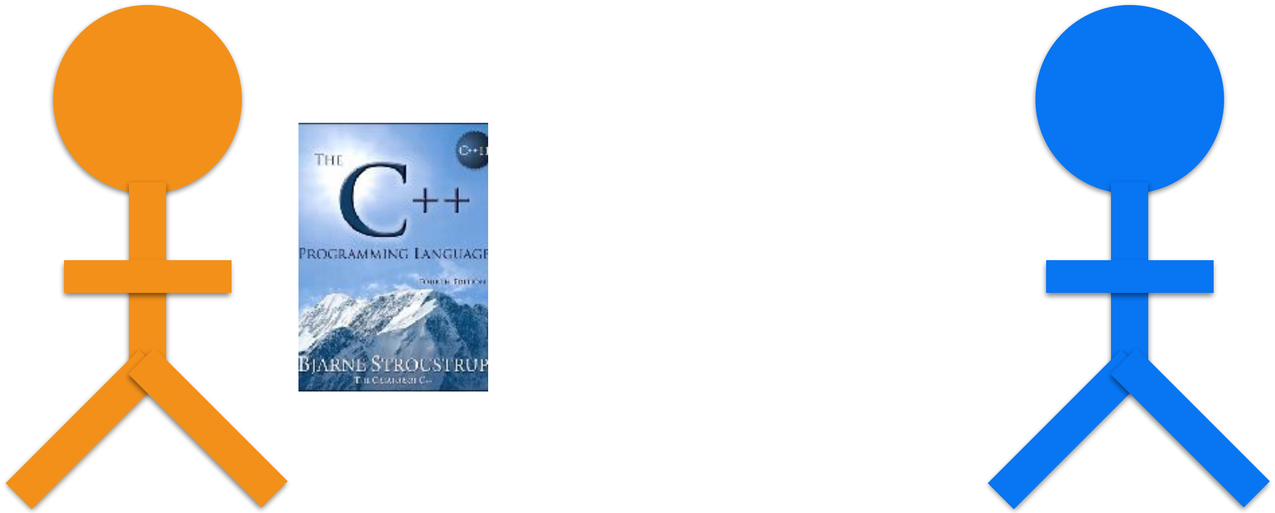
C++

~ *Ownership and Borrowing* ~

Type	Ownership	Alias?	Mutate?
T	Owned		✓

Ownership

n. The act, state, or right of possessing something.



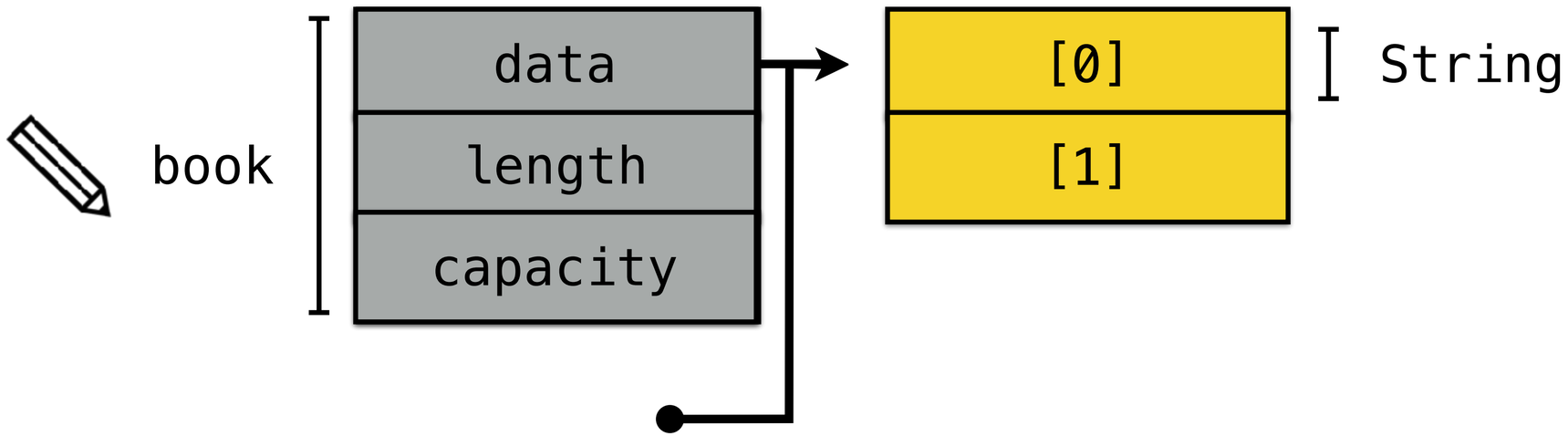
```
fn main() {
    let mut book = Vec::new();
    book.push(…);
    book.push(…);
    publish(book);
    publish(book);
}
```

```
fn publish(book: Vec<String>) {
    …
}
```

Give ownership.

Error: use of moved value: `book`

Take ownership of the vector



Ownership

“Manual” memory management in Rust:

Values owned by **creator**.

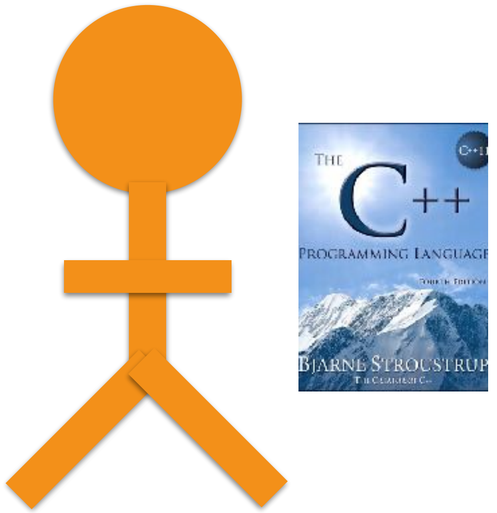
Values **moved** via assignment.

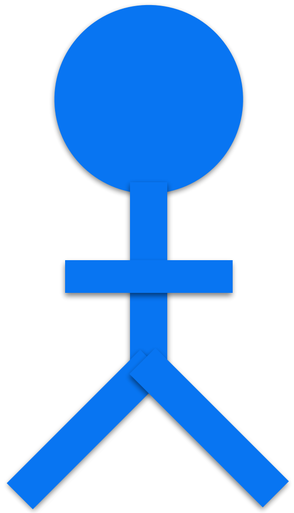
When final owner returns, **value is freed**.

Feels invisible.

Borrow

v. To receive something with the promise of returning it.





~ *Ownership and Borrowing* ~

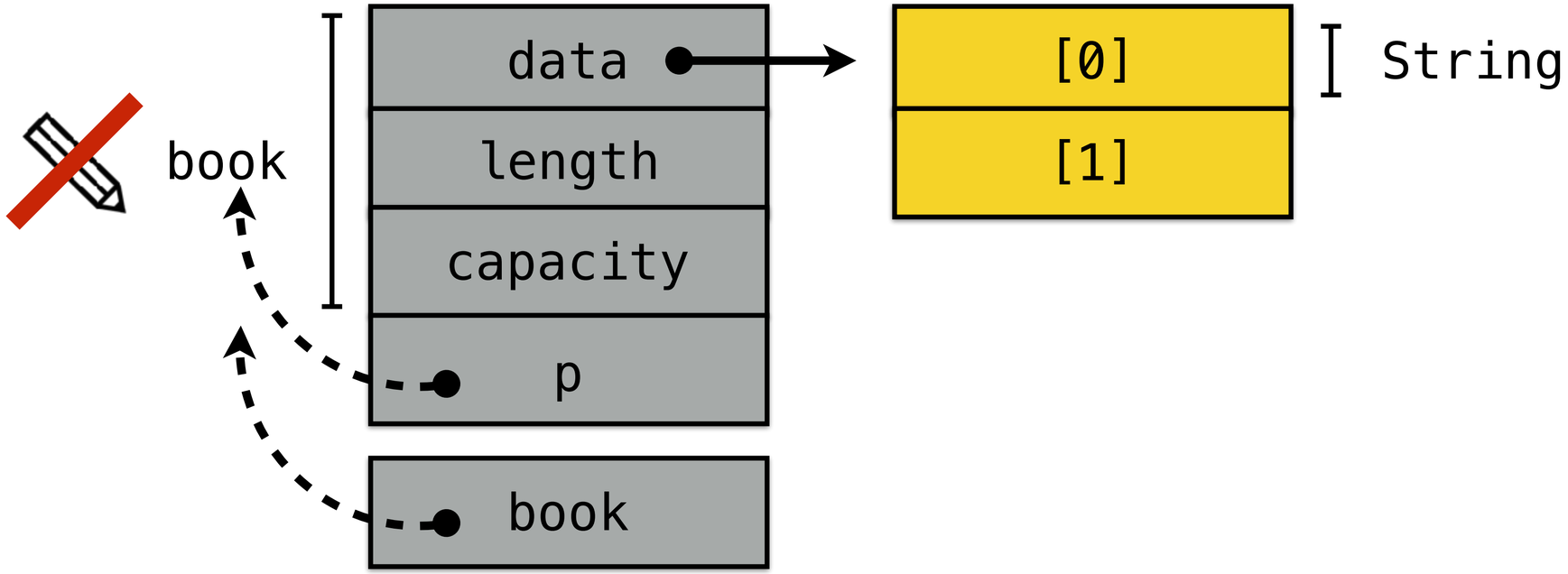
Type	Ownership	Alias?	Mutate?
T	Owned		✓
&T	Shared reference	✓	

```
fn main() {
  let mut book = Vec::new();
  book.push(…);
  book.push(…);
  let p = &book;
  publish(p);
  publish(p);
}
```

```
fn publish(book: &Vec<String>) {
  …
}
```

Borrow the vector, creating a reference

Change type to a **reference** to a vector



Shared borrow

Shared data: immutable

```
let mut book = Vec::new();
book.push(…);
{
    let r = &book;
    book.push(…);
    r.push(…);
}
book.push(…);
```

book **mutable** here

book **borrowed** here

cannot mutate while shared *

r goes out of scope; borrow ends

now book is **mutable** again

**** Actually: mutation only under controlled circumstances***

~ *Ownership and Borrowing* ~

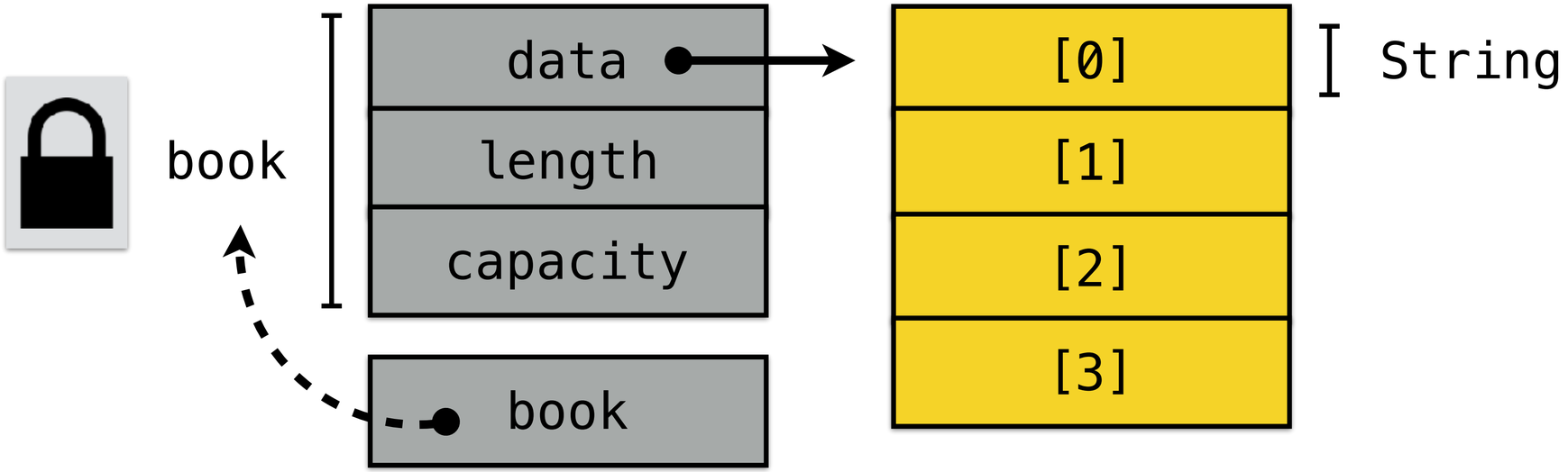
Type	Ownership	Alias?	Mutate?
T	Owned		✓
&T	Shared reference	✓	
&mut T	Mutable reference		✓

```
fn main() {
  let mut book = Vec::new();
  book.push(…);
  book.push(…);
  edit(&mut book);
  edit(&mut book);
}
```

Mutable borrow

```
fn edit(book: &mut Vec<String>) {
  book.push(…);
}
```

Mutable reference
to a vector



Mutable borrow

Mutable references: no other access

```
let mut book = Vec::new();

book.push(…);

{
    let r = &mut book;
    book.len();
    r.push(…);
}

book.push(…);
```

book **mutable** here

book **borrowed** here

cannot **access** while borrowed

but &**mut ref** can mutate

r goes out of scope; borrow ends

borrow ended; **accessible** again

Lifetime of a reference

```
let mut book = Vec::new();
…
{
    let r: &String = &book[0];
    …
}
```

‘l

```
let r: &String = &book;
```

```
let r: &’l String = &book;
```

```
fn first<‘a>(v: &’a Vec<String>) -> &’a String {
    return &v[0];
}
```

“Returns a reference derived from `v`”

```
fn first(v: &Vec<String>) -> &String {
    return &v[0];
}
```

(more common shorthand)

```
const git_tree_entry *
git_tree_entry_byname(const git_tree *tree,
                      const char *filename);
```

This returns a git_tree_entry that is owned by the git_tree. You don't have to free it, but you must not use it after the git_tree is released.

```
impl Tree {
  fn by_name<'a>(&'a self, filename: &str) -> &'a TreeEntry {
    ..
  }
}
```

"Returns a reference derived from `self`"

```
const git_tree_entry *
git_tree_entry_byname(const git_tree *tree,
                      const char *filename);
```

This returns a git_tree_entry that is owned by the git_tree. You don't have to free it, but you must not use it after the git_tree is released.

Read-only, yes, but mutable through an alias?

Will `git_tree_entry_byname` keep this pointer?
Start a thread using it?

```
impl Tree {
  fn by_name<'a>(&'a self, filename: &str) -> &'a TreeEntry {
    ..
  }
}
```

Borrowed string
Does not escape `by_name`
Immutable while `by_name` executes

Photo credit: Andy Leppard
https://www.flickr.com/photos/creativecomputer/261445720/

```
trait Clone {
  fn clone(&self) -> Self;
}

impl<T: Clone> Clone for Vec<T> {
  fn clone(&self) -> Vec<T> {
    let mut v = Vec::new();
    for elem in self {
        v.push(elem.clone());
    }
    return v;
  }
}
```

Implemented for a given type

Method that borrows its receiver

Implementation for vectors

Create new vector

Iterate (using references)…

…push clone of each element.

Return `v`

Type-check model: check the generic definition once

Runtime model: monomorphized, like C++

Marker traits

	✅	🚫

`// “Safe to send between threads”`
`trait Send { }`
	`String`
	`u32`
	`Arc<String>`
		`Rc<String>`

`// “Safe to memcpy”` `trait Copy { }`	`u32` `f32`	`String` `Rc<String>`

Parallelism

Photo credit: Dave Gingrich
https://www.flickr.com/photos/ndanger/2744507570/

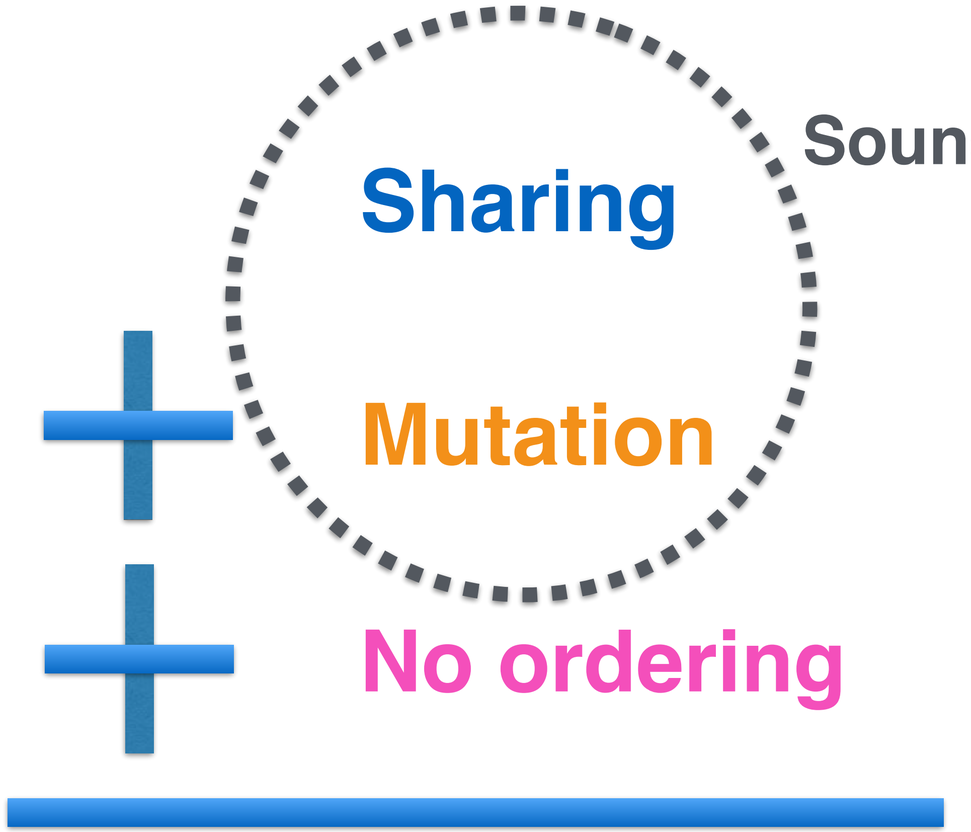
Library-based concurrency

Originally: Rust had message passing built into the language.

Now: library-based, multi-paradigm.

Libraries leverage **ownership and traits** to avoid data races.

Data races



Sound familiar?

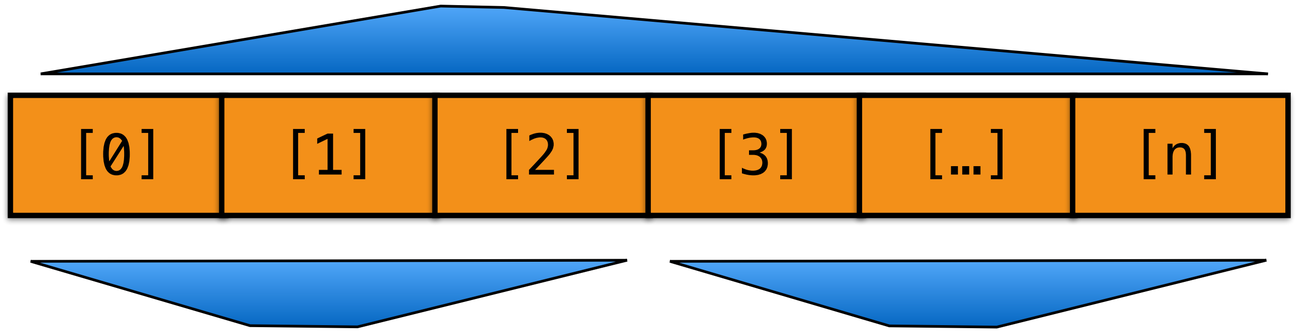
Data race

```
fn qsort(vec: &mut [i32]) {
  if vec.len() <= 1 { return; }
  let pivot = vec[random(vec.len())];
  let mid = vec.partition(vec, pivot);
  let (less, greater) = vec.split_at_mut(mid);
  |
}
```

`&mut` can safely go

```
fn split_at_mut<'a>(v: &'a mut [T], …) -> (&'a mut [T], &'a mut [T])
```

vec: &mut [i32]



less: &mut [i32] greater: &mut [i32]

Parallel iterators

```
vec1.par_iter()
    .zip(vec2)
    .map(|(i, j)| i * j)
    .sum()
```

```
trait ParallelIterator {
    type Item;
    …
}
```

```
join(
  || /* seq iter */,
  || /* seq iter */)
```

~ Concurrency paradigms ~

Paradigm	Ownership?	Borrowing?
Fork-join		✓
Message Passing	✓	
Locking	✓	✓
Lock-free	✓	✓
Futures	✓	✓
…		

Unsafe

Vision: An Extensible Language

Core language:

Ownership and borrowing

Libraries:

Reference-counting

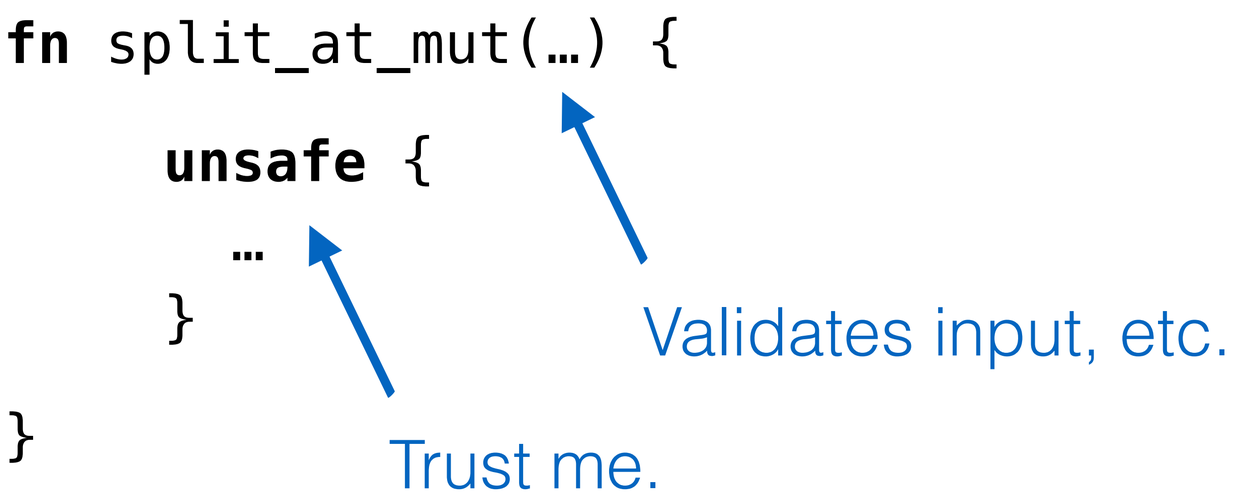
Files

Parallel execution

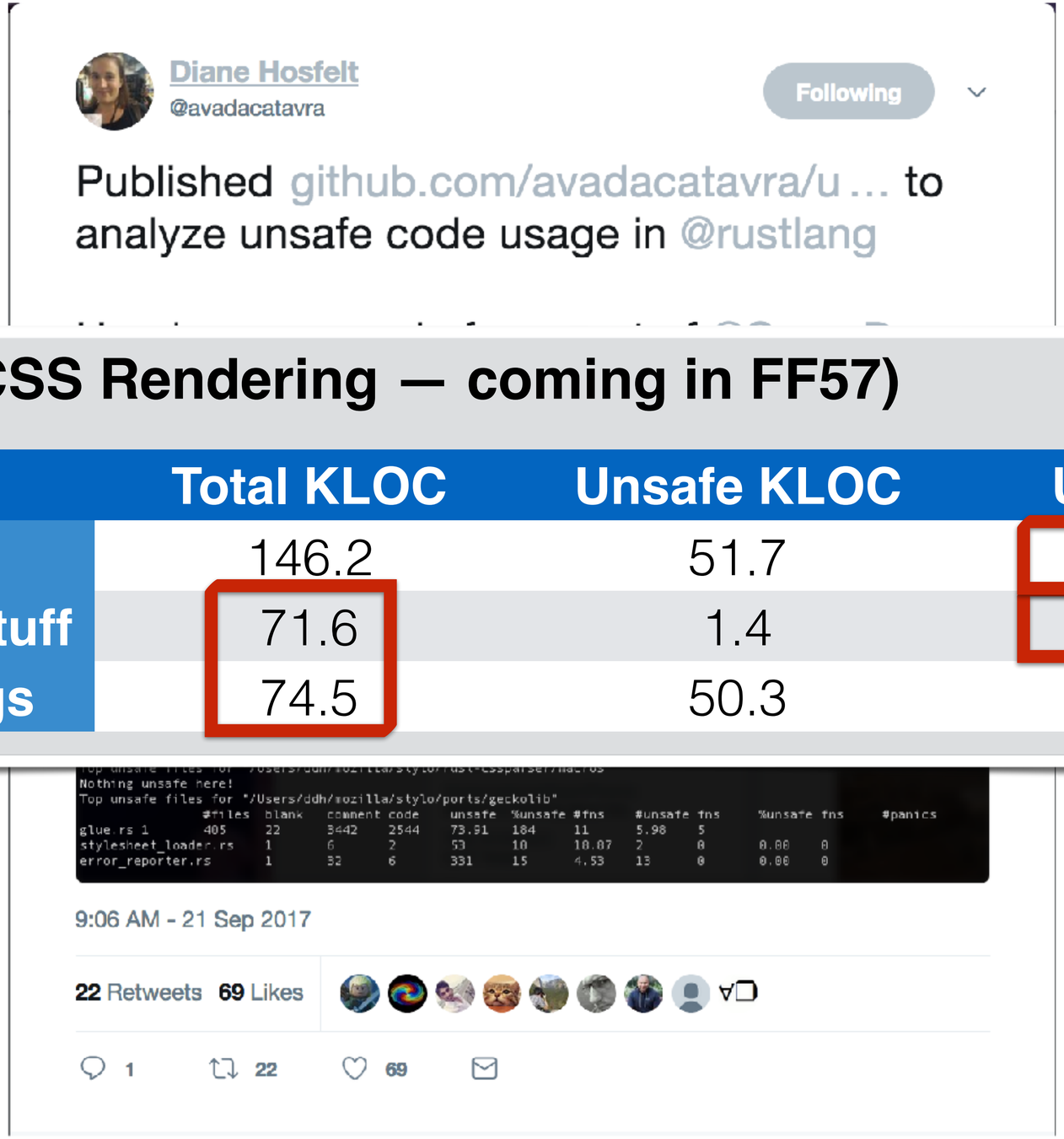
…

Use ownership/ borrowing to enforce correct usage.

Safe abstractions

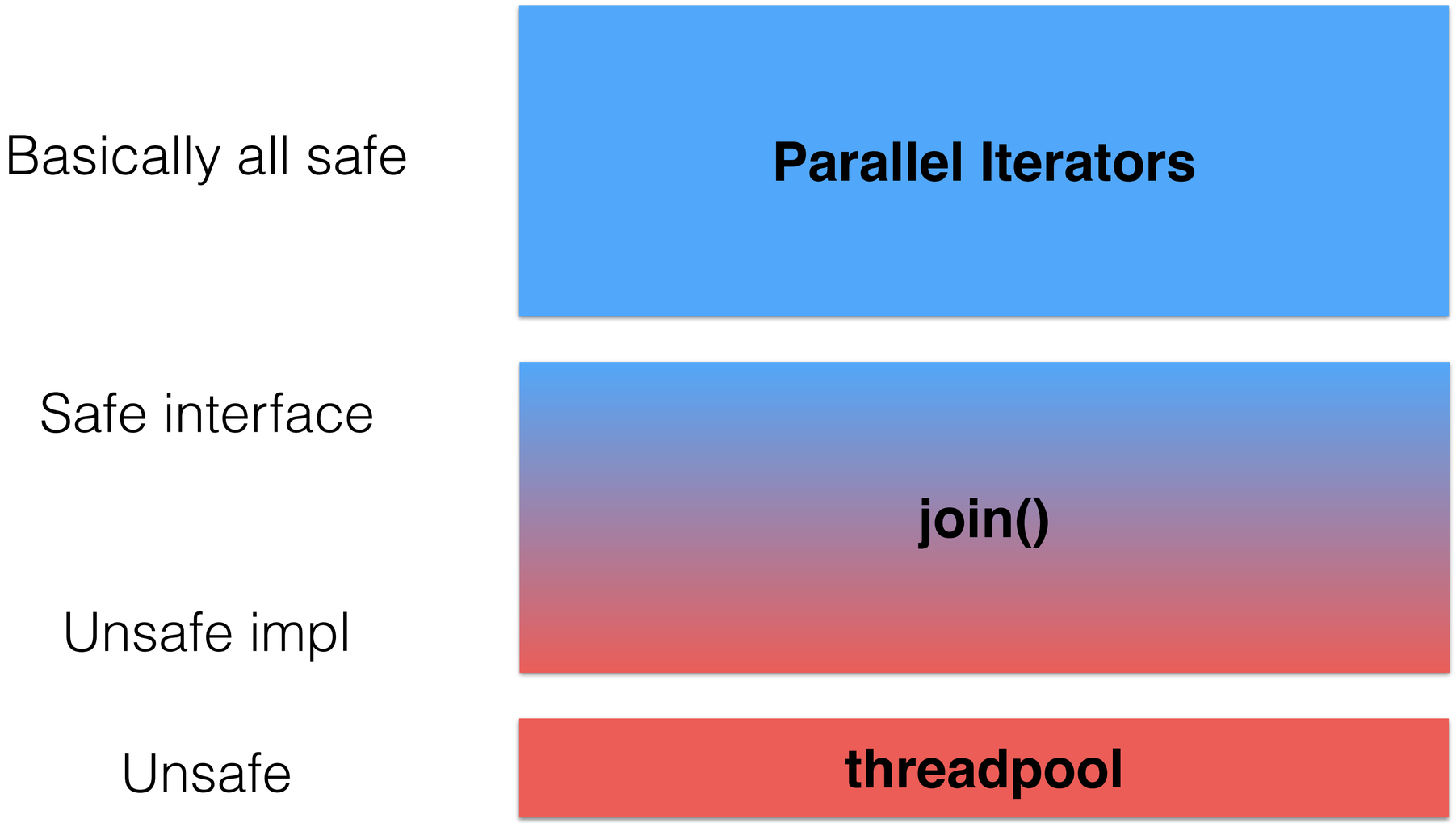


Ownership/borrowing/traits give tools to enforce **safe abstraction boundaries.**



Stylo (Parallel CSS Rendering — coming in FF57)

	Total KLOC	Unsafe KLOC	Unsafe %
Total	146.2	51.7	35%
Interesting stuff	71.6	1.4	1.9%
FFI Bindings	74.5	50.3	67.4%


Basically all safe
Parallel Iterators
Safe interface
join()
Unsafe impl
Unsafe
threadpool

DOCS.RS | Releases | Rust

crossbeam 0.2.10

Support for lock-free data structures, synchronizers, and parallel programming

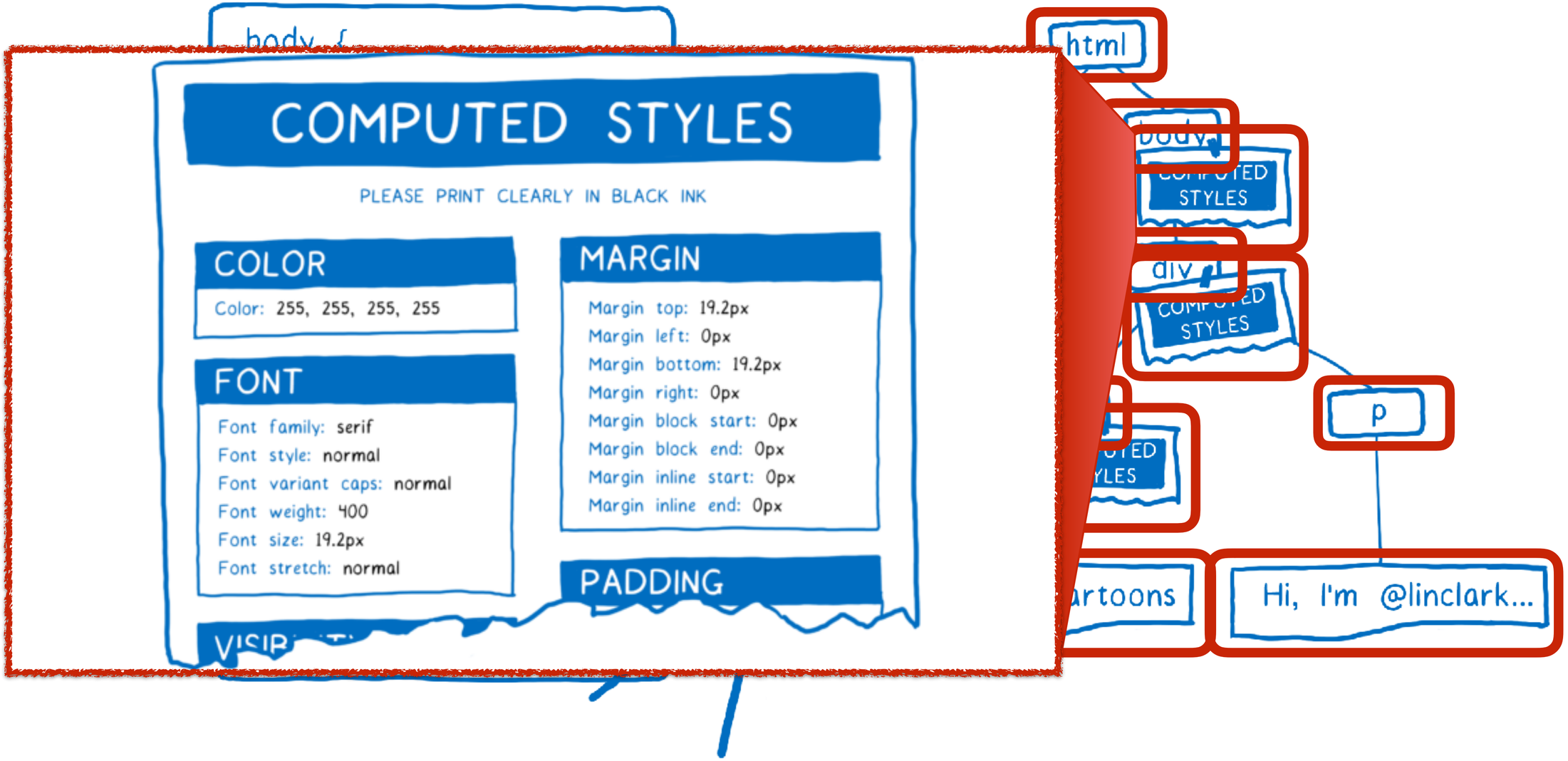
Documentation | Crate | Source

“Partially safe:”

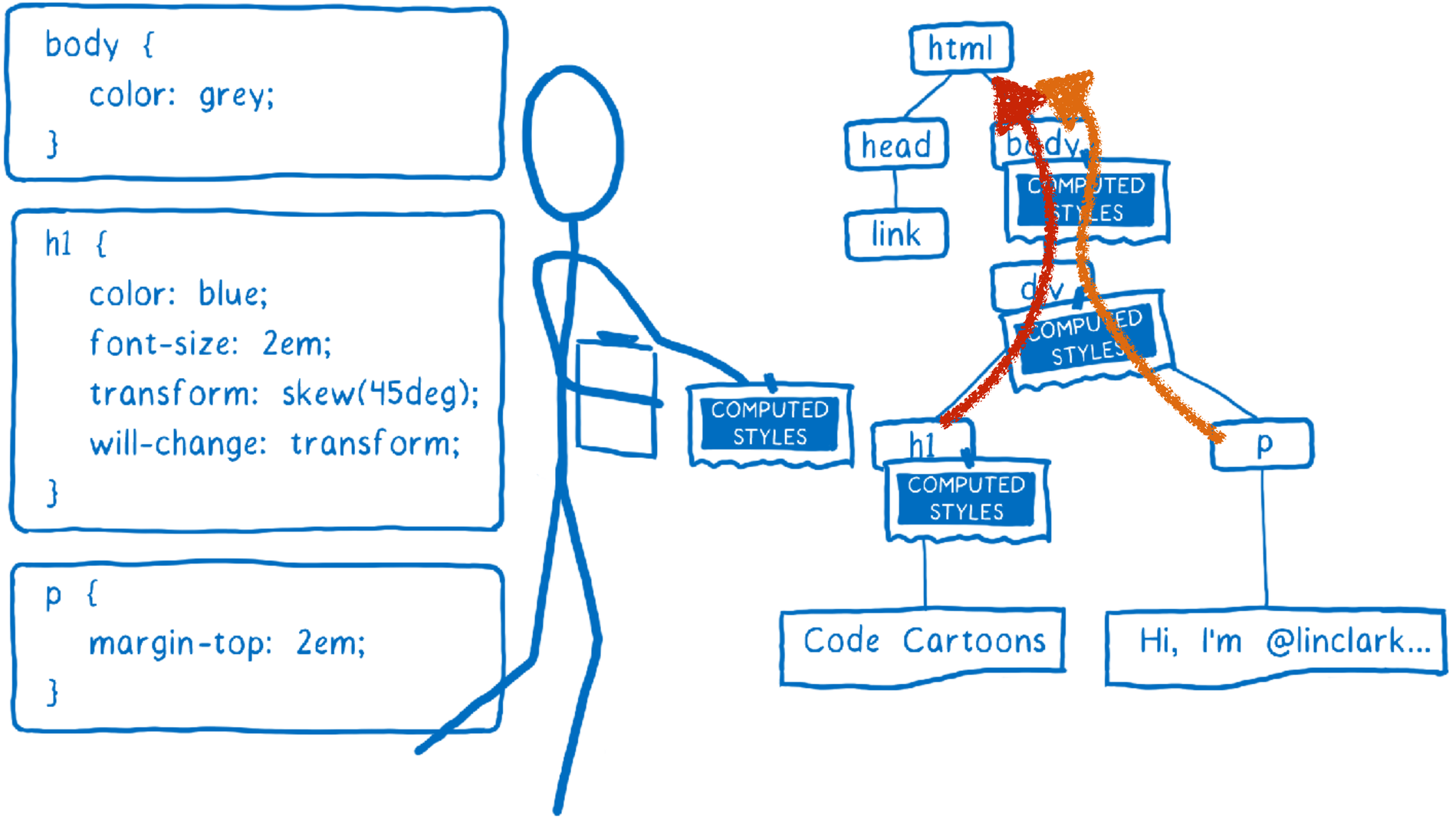
- API contains just one unsafe method
- Relatively simple correctness criteria
- Library handles the rest


Mission accomplished
Rust in Firefox 48

STYLE


body {
COMPUTED STYLES
PLEASE PRINT CLEARLY IN BLACK INK
COLOR
Color: 255, 255, 255, 255
FONT
Font family: serif
Font style: normal
Font variant caps: normal
Font weight: 400
Font size: 19.2px
Font stretch: normal
MARGIN
Margin top: 19.2px
Margin left: 0px
Margin bottom: 19.2px
Margin right: 0px
Margin block start: 0px
Margin block end: 0px
Margin inline start: 0px
Margin inline end: 0px
PADDING
html
STYLES
STYLES
p
Hi, I'm @linclark...

STYLE


body {
color: grey;
}
h1 {
color: blue;
font-size: 2em;
transform: skew(45deg);
will-change: transform;
}
p {
margin-top: 2em;
}
COMPUTED STYLES
html
head
link
body
COMPUTED STYLES
div
COMPUTED STYLES
h1
COMPUTED STYLES
p
Code Cartoons
Hi, I'm @linclark...

Bug 631527

Parallelize selector matching

Get help with this page

NEW Assigned to dzbarsky

Status (NEW bug with no priority)

Product: Core

Component: CSS Parsing and Computation

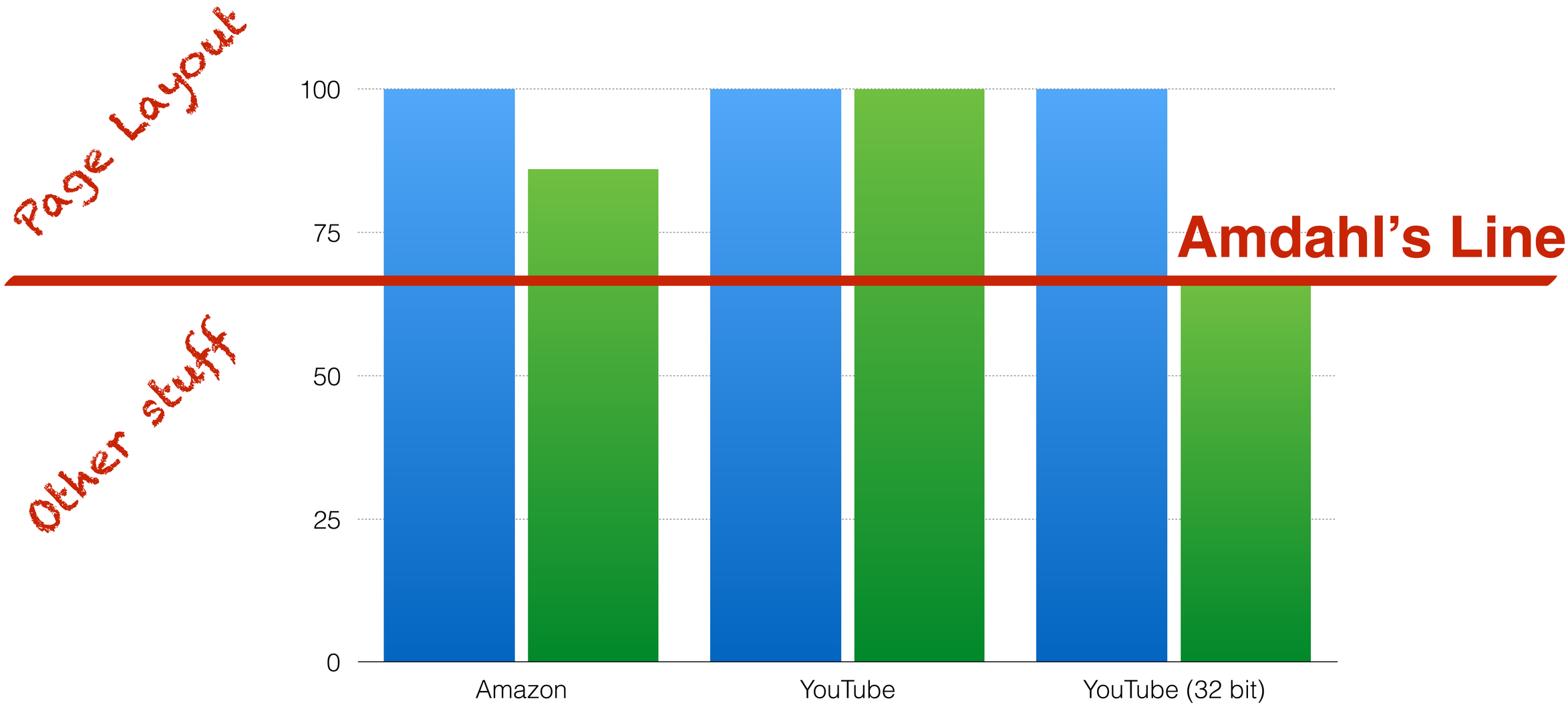
Status: NEW

Reported: 7 years ago

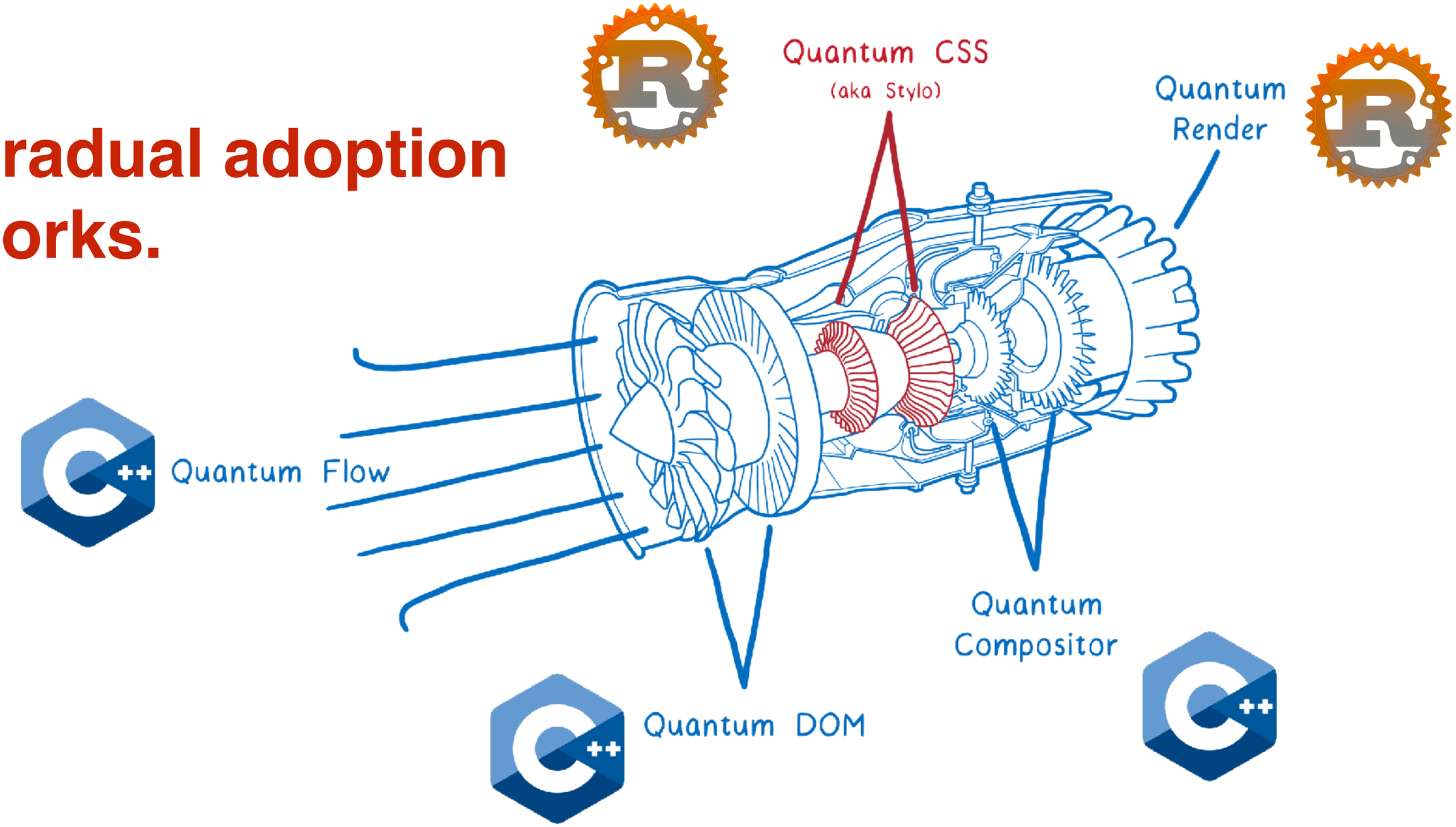
Safety = Eat your spinach!

Photo credit: Salim Virji
https://www.flickr.com/photos/salim/8594532469/

Initial load times (relative to today)



Gradual adoption works.



Community

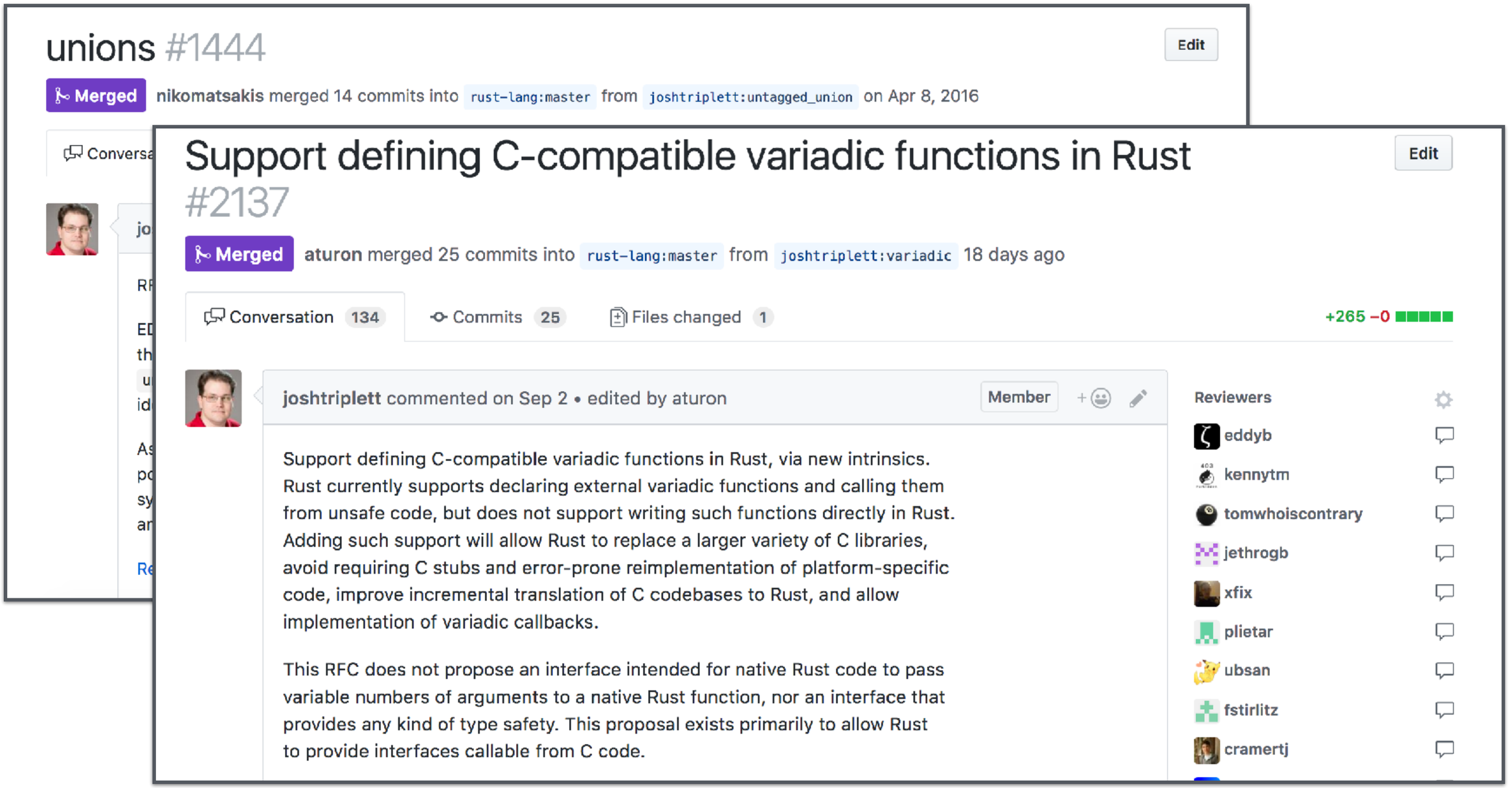
Photo credit: David McSpadden
https://www.flickr.com/photos/familyclan/15535822737/

Open and welcoming

From http://jvns.ca/blog/2016/09/11/rustconf-keynote/

Almost 40 working groups spread across 7 Rust "teams"

RFC Process


unions #1444
Edit
Merged
nikomatsakis merged 14 commits into rust-lang:master from joshtriplett:untagged_union on Apr 8, 2016
Support defining C-compatible variadic functions in Rust #2137
Edit
Merged
aturon merged 25 commits into rust-lang:master from joshtriplett:variadic 18 days ago
Conversation 134
Commits 25
Files changed 1
+265 −0
joshtriplett commented on Sep 2 • edited by aturon
Member
Support defining C-compatible variadic functions in Rust, via new intrinsics. Rust currently supports declaring external variadic functions and calling them from unsafe code, but does not support writing such functions directly in Rust. Adding such support will allow Rust to replace a larger variety of C libraries, avoid requiring C stubs and error-prone reimplementation of platform-specific code, improve incremental translation of C codebases to Rust, and allow implementation of variadic callbacks.
This RFC does not propose an interface intended for native Rust code to pass variable numbers of arguments to a native Rust function, nor an interface that provides any kind of type safety. This proposal exists primarily to allow Rust to provide interfaces callable from C code.
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Interested in Rust?

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users.rust-lang.org

#rust-beginners on irc.mozilla.org

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