



Rust and what's this thing for?



Abc Xyz
@dura_lex

1. Foreword

2. What is Rust?

3. (Un)safe

4. Syntax

5. Ecosystem

6. Popularity

7. Experience and Pitfalls

8. Summary

Foreword







- Since 1.0.0
- Scope (by time)
 - Bindings (FFI – foreign function interface)
 - Analyzers
 - CLI (TUI) tools for PC and IoT
 - GUI for fun
 - Libraries
 - RE
- Nim, Crystal, Zig, Pony





What is Rust?

“Rust is a multi-paradigm systems programming language focused on safety, especially safe concurrency”.

— Wikipedia

“Rust is a systems programming language that runs blazingly fast, prevents nearly all segfaults, and guarantees thread safety”.

— www.rust-lang.org (2015)

“Empowering everyone to build reliable and efficient software”.

— www.rust-lang.org

What is Rust?

Quick facts about Rust

- Started by Mozilla (sponsorship & support) employee Graydon Hoare
- Influenced by C++ & Haskell and others
- First announced by Mozilla in 2010
- Community driven development
- 88,281 commits on GitHub
- First stable release: 1.0 in May 2015
- Latest stable release: 1.32

What is Rust?

Why Rust?

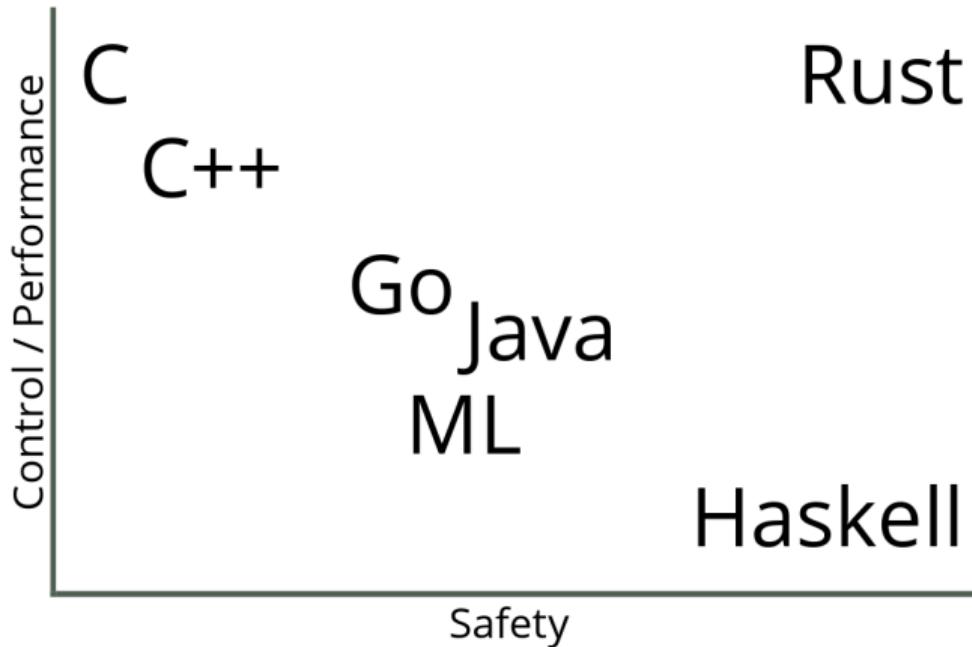


- Performance
 - Fast, memory-efficient
 - No runtime or garbage collector
 - Zero-cost abstractions
- Reliability
 - Rich type system
 - Ownership model
- Productivity
 - Documentation
 - Friendly compiler
 - Top-notch tooling

(Un)safe

(Un)safe

Control vs Safety



(Un)safe

What's wrong with systems languages?

What's wrong with systems languages?

- It's difficult to write secure code
- It's very difficult to write multithreaded code

Rust?

(Un)safe

Problems

Memory corruption

- Using uninitialized memory
- Using non-owned memory (null pointer, dangling pointer dereference, out of bounds error)
- Using memory beyond the memory that was allocated (buffer overflow)
- Faulty heap memory management (memory leaks, freeing non-heap or un-allocated memory)



(Un)safe

Ownership and Borrowing



Ownership and Borrowing

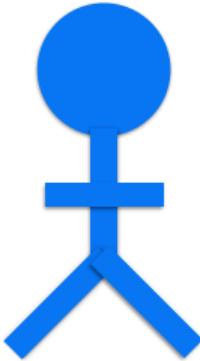
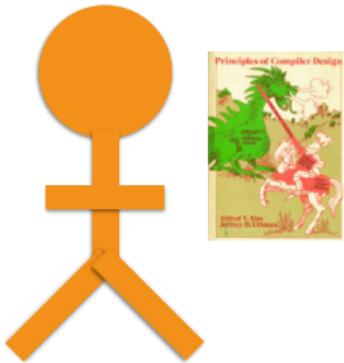
Nicholas Matsakis

Ownership

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

Borrow

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



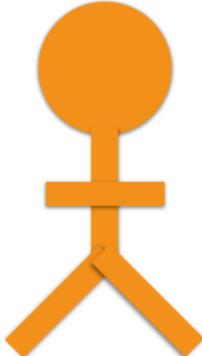
Ownership



Ownership

```
fn main() {  
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    helper(name);  
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}
```

```
fn helper(name: String) {  
    println!(...);  
}
```

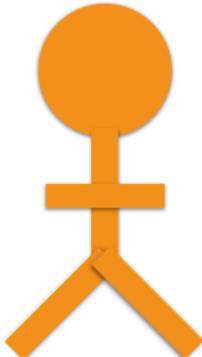


Ownership

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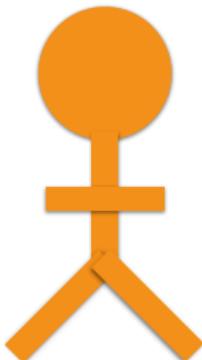
Ownership

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}
```



```
fn helper(name: String) {  
    println!(...);  
}
```

Take ownership
of a String



Ownership

```
fn main() {  
    let name = format!("...");  
    helper(name);  
    helper(name);  
}
```

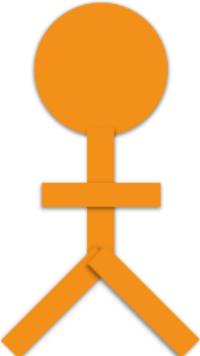


```
fn helper(name: String) {  
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Ownership

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fn main() {  
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Ownership

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fn main() {  
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```

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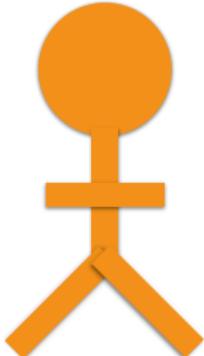
Ownership

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```



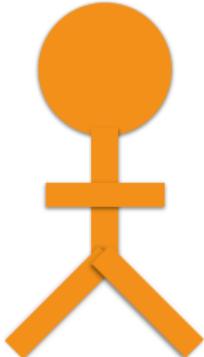
Ownership

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Ownership

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Ownership

```
fn main() {  
    let name = format!("...");  
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}  
↑
```

```
fn helper(name: String) {  
    println!(...);  
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```

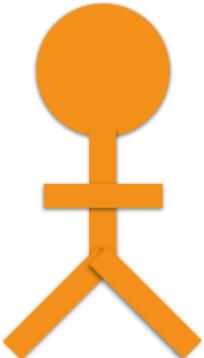
Error: use of moved value: `name`



Ownership

```
void main() {  
    Vector name = ...;  
    helper(name);  
    helper(name);  
}
```

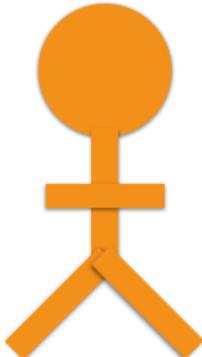
```
void helper(Vector name) {  
    ...  
}
```



“Ownership” in Java

```
void main() {  
    Vector name = ...;  
    → helper(name);  
    helper(name);  
}
```

```
void helper(Vector name) {  
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```



“Ownership” in Java

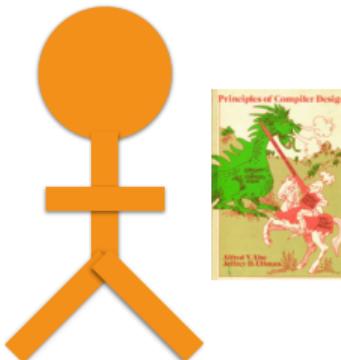
```
void main() {  
    Vector name = ...;  
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```
void helper(Vector name) {
```

```
    ...  
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```



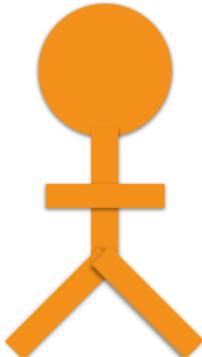
Take reference
to Vector



“Ownership” in Java

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void main() {  
    Vector name = ...;  
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}
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void helper(Vector name) {  
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“Ownership” in Java

```
void main() {  
    Vector name = ...;  
    helper(name);  
    helper(name);  
}
```



```
void helper(Vector name) {  
    ...  
}
```



“Ownership” in Java

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void main() {  
    Vector name = ...;  
    helper(name);  
    helper(name);  
}
```



```
void helper(Vector name) {  
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    Vector name = ...;  
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“Ownership” in Java

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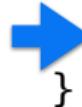


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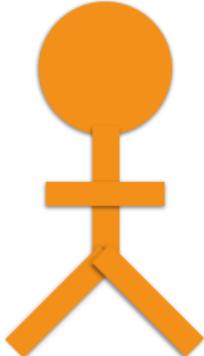


“Ownership” in Java

```
void main() {  
    Vector name = ...;  
    helper(name);  
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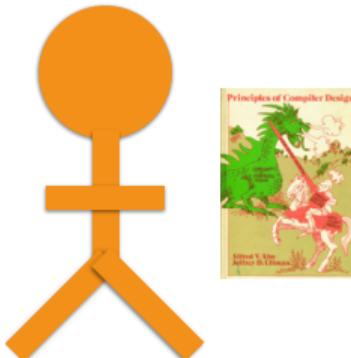


“Ownership” in Java

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void main() {  
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“Ownership” in Java

```
void main() {  
    Vector name = ...;  
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    helper(name);  
}
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```
void helper(Vector name) {  
    new Thread(...);  
}
```



“Ownership” in Java

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“Ownership” in Java

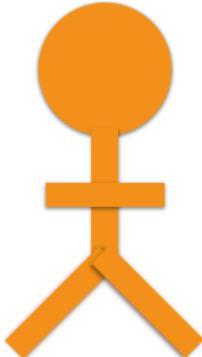
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```

Clone

```
fn main() {  
    let name = format!("...");  
    helper(name.clone());  
    helper(name);  
}
```

```
fn helper(name: String) {  
    println!(...);  
}
```



Clone

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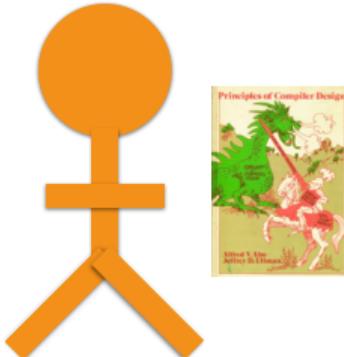


Clone

```
fn main() {  
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}
```

Copy the String

```
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    println!(...);  
}
```



Clone

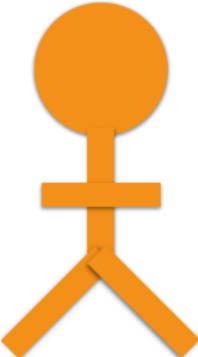
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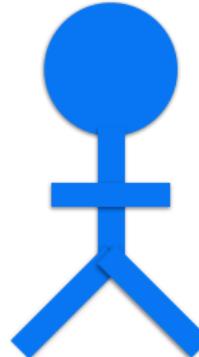
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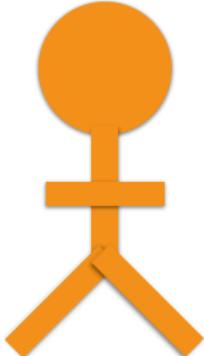


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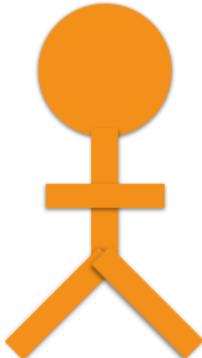
```
fn helper(name: String) {  
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Copy (auto-Clone)

```
fn main() {  
    let count = 22;  
    helper(count);  
    helper(count);  
}
```

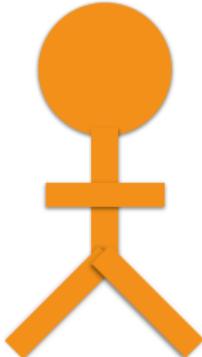
```
fn helper(count: i32) {  
    println!(..);  
}
```



Copy (auto-Clone)

```
fn main() {  
    ➔ let count = 22;  
    helper(count);  
    helper(count);  
}
```

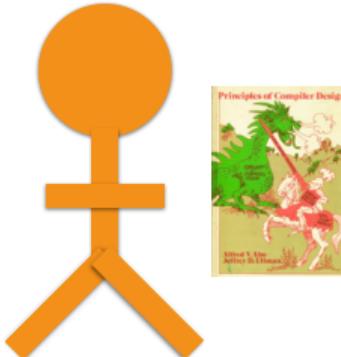
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fn helper(count: i32) {  
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}  
i32 is a Copy type
```



Copy (auto-Clone)

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fn main() {  
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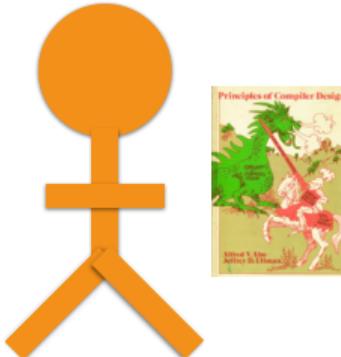
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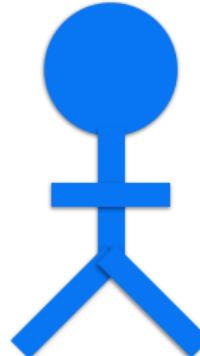
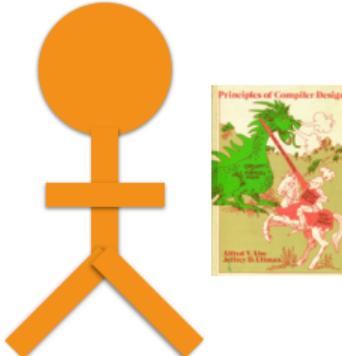
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fn helper(count: i32) {  
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i32 is a Copy type



Non-copyable: Values **move** from place to place.

Example: *money*

Clone: Run custom code to make a copy.

Example: *strings*

Copy: Type is implicitly copied when referenced.

Example: *integers or floating-point numbers*



Borrowing: Shared Borrows



Borrowing: Shared Borrows



Borrowing: Shared Borrows

```
fn main() {  
    let name = format!("...");  
    let reference = &name;  
    helper(reference);  
    helper(reference);  
}  
→
```

```
fn helper(name: &String) {  
    println!(...);  
}
```



Shared borrow

```
fn main() {  
    let name = format!("...");  
    let reference = &name;  
    helper(reference);  
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```

Change type to a
reference to a String



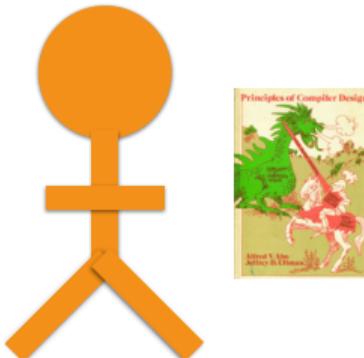
Shared borrow

```
fn main() {  
    let name = format!("...");  
    let reference = &name;  
    helper(reference);  
    helper(reference);  
}
```

Lend the string,
creating a reference

```
fn helper(name: &String) {  
    println!(...);  
}
```

Change type to a
reference to a String



Shared borrow

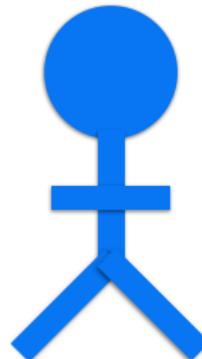
```
fn main() {  
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    ➔ helper(reference);  
    helper(reference);  
}
```

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fn helper(name: &String) {  
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```



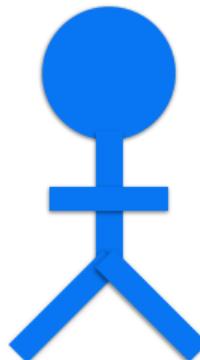
Shared borrow

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Shared borrow

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fn main() {  
    let name = format!("...");  
    let reference = &name;   
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    helper(reference);  
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fn helper(name: &String) {  
    println!(...);  
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```



Shared borrow

```
fn main() {  
    let name = format!("...");  
    let reference = &name; ➔  
    helper(reference);  
    helper(reference);  
}  
  
fn helper(name: &String) {  
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}
```



Shared borrow

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fn main() {  
    let name = format!("...");  
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    helper(reference);  
    helper(reference);  
}  
  
fn helper(name: &String) {  
    println!(...);  
}
```



Shared borrow

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fn main() {  
    let name = format!("...");  
    let reference = &name;  
    helper(reference);  
    helper(reference);  
}  
  
→ }
```

```
fn helper(name: &String) {  
    println!(...);  
}
```

Shared borrow

Shared == Immutable

```
fn helper(name: &String) {  
    println!("{}", name);  
}
```

```
fn helper(name: &String) {  
    name.push_str("foo");  
}
```

Shared == Immutable

```
fn helper(name: &String) {  
    println!("{}", name); ← OK. Just reads.  
}
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Shared == Immutable

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fn helper(name: &String) {  
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Shared == Immutable

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```
error: cannot borrow immutable borrowed content `*name`  
      as mutable  
      name.push_str("s");  
      ^~~~
```

Shared == Immutable^{*}

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fn helper(name: &String) {  
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```

```
error: cannot borrow immutable borrowed content `*name`  
      as mutable  
      name.push_str("s");  
      ^~~~
```

* **Actually:** mutation only in **controlled circumstances**.

Play time



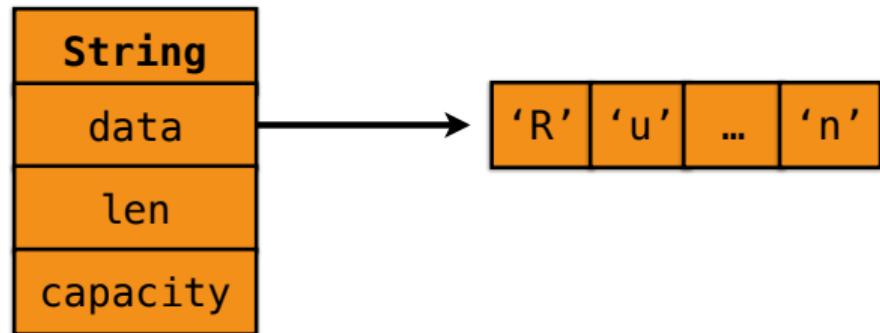
Waterloo, Cassius Coolidge, c. 1906

```
fn main() {  
    let name = format!("...");  
    helper(&name[1..]);  
    helper(&name);  
}  
  
fn helper(name: &str) {  
    println!(...);  
}
```

Looks like other languages:
• Python: name[1:]
• Ruby: name[1..-1]
But no copying at runtime.

```
fn main() {  
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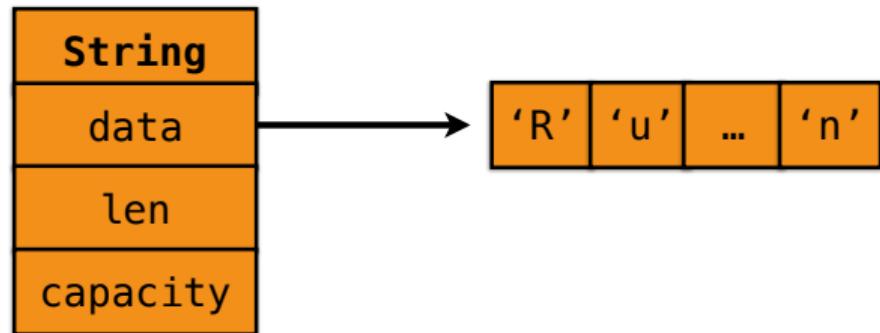
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Looks like other languages:
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```

```
fn helper(name: &str) {  
    println!(...);  
}
```

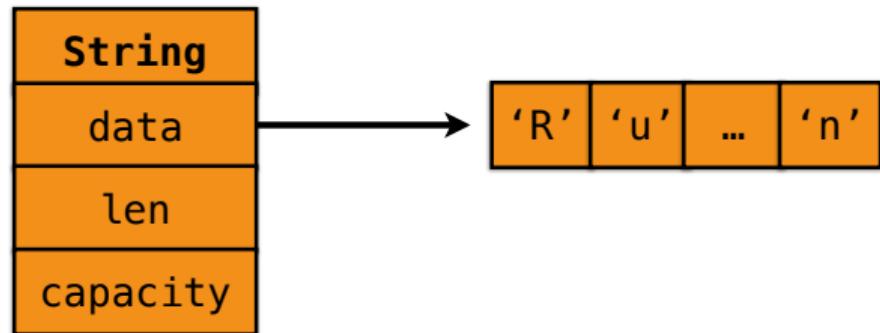


Looks like other languages:
• Python: `name[1:]`
• Ruby: `name[1..-1]`
But no copying at runtime.

```
fn main() {  
    let name = format!("...");  
    helper(&name[1..]);  
    helper(&name);  
}
```

```
fn helper(name: &str) {  
    println!(...);  
}
```

Change type from `&String`
to a **string slice**, `&str`



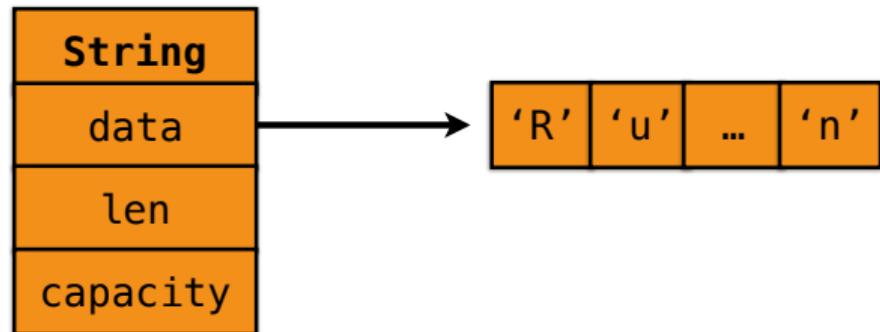
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```
fn main() {  
    let name = format!("...");  
    helper(&name[1..]);  
    helper(&name);  
}
```

Lend some of
the string

```
fn helper(name: &str) {  
    println!(...);  
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Change type from `&String`
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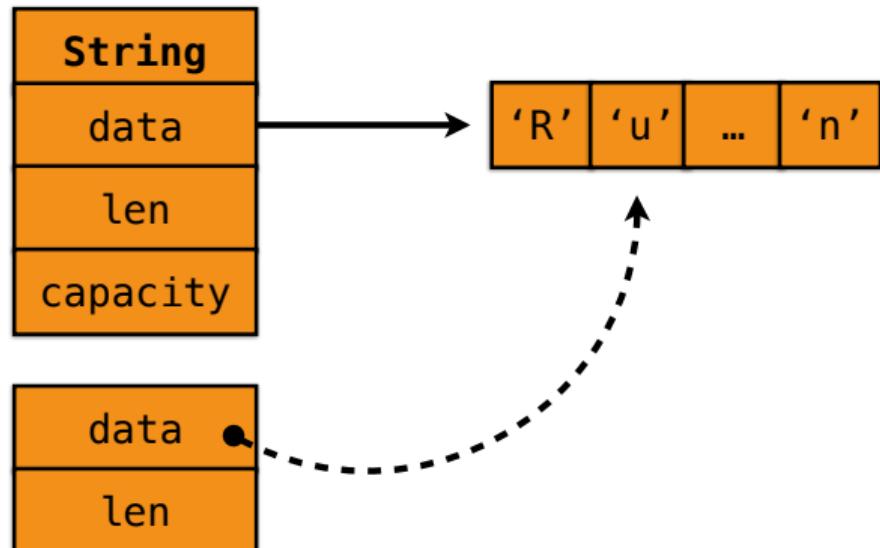
```
fn main() {  
    let name = format!("...");  
    helper(&name[1..]);  
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}
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Lend some of
the string

```
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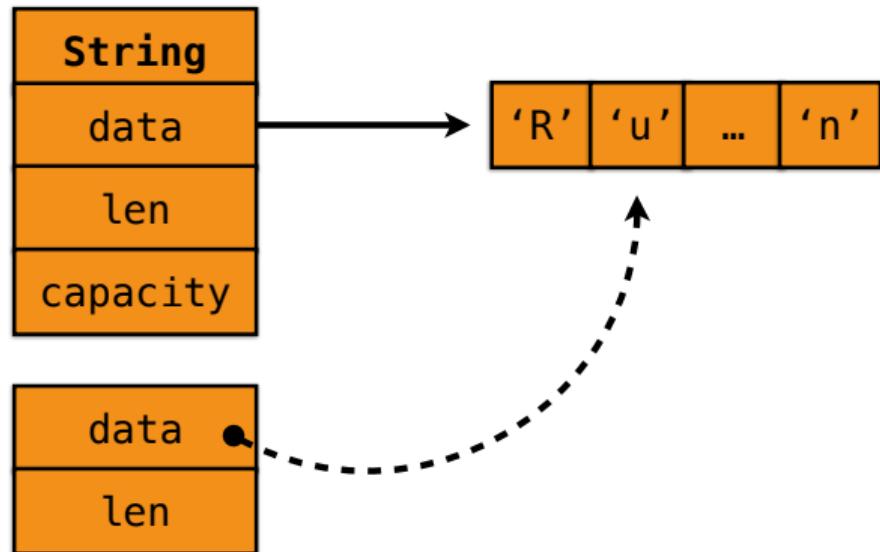


```
fn main() {  
    let name = format!("...");  
    helper(&name[1..]);  
    helper(&name);  
}
```



```
fn helper(name: &str) {  
    println!(...);  
}
```

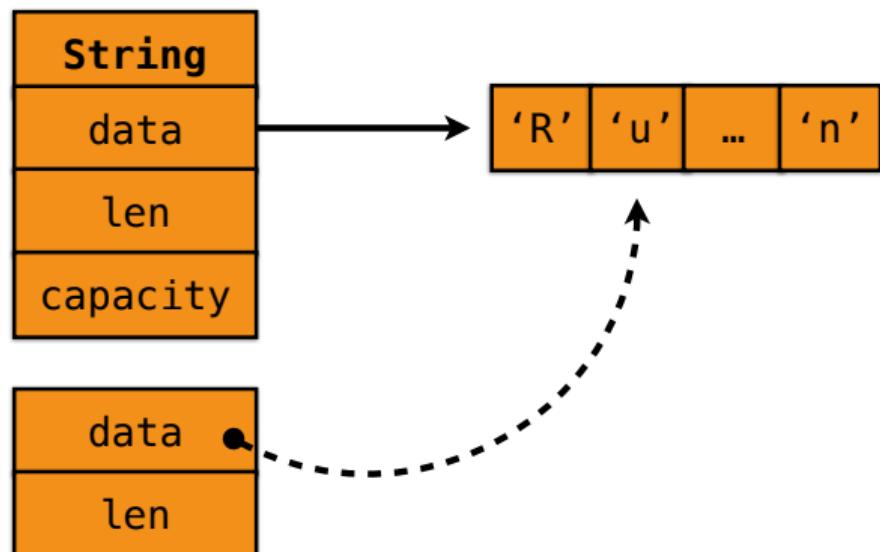
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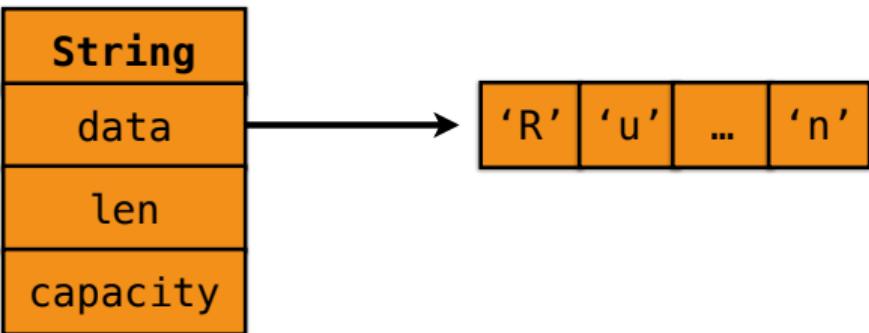
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Looks like other languages:
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    let name = format!("...");  
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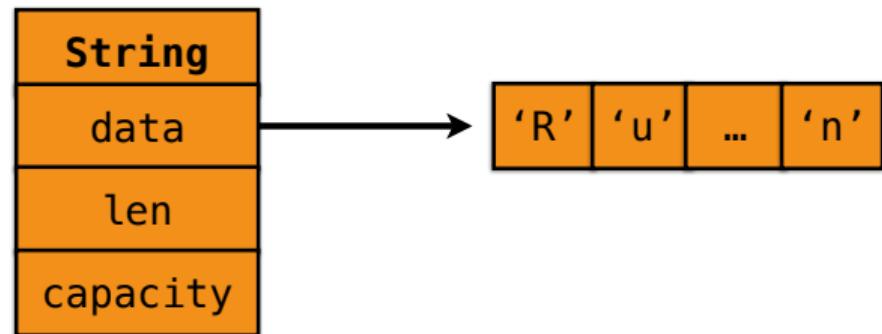
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```

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fn helper(name: &str) {  
    println!(...);  
}
```



Looks like other languages:
• Python: `name[1:]`
• Ruby: `name[1..-1]`
But no copying at runtime.

High-level code, low-level efficiency

```
for word in line.split(' ') {  
    sum += word.len();  
}
```

No copying, no allocations.

High-level code, low-level efficiency

```
for word in line.split(' ') {  
    sum += word.len();  
}
```

Iterator over slices
borrowed from `line`.

No copying, no allocations.

High-level code, low-level efficiency

```
for word in line.split(' ') {  
    sum += word.len();  
}
```

Iterator over slices
borrowed from `line`.

String
data
len
capacity

→ “Sing, Goddess, of Achilles’ rage, black and murderous...

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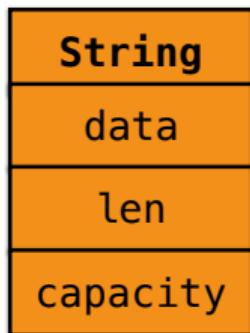
data
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No copying, no allocations.

High-level code, low-level efficiency

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for word in line.split(' ') {  
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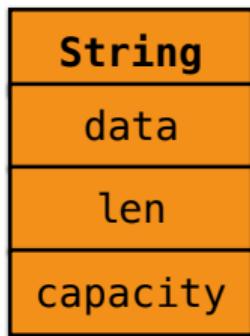


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for word in line.split(' ') {  
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No copying, no allocations.



Borrowing: Mutable Borrows



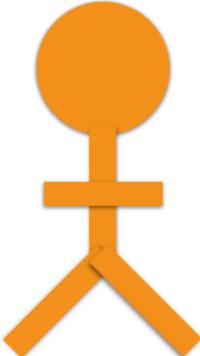
Borrowing: Mutable Borrows



Borrowing: Mutable Borrows

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```

```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```



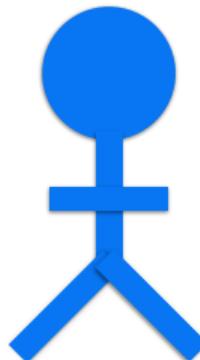
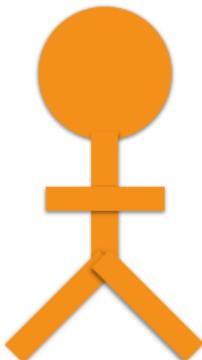
Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```



```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```

Take a **mutable** reference to a String



Mutable borrow

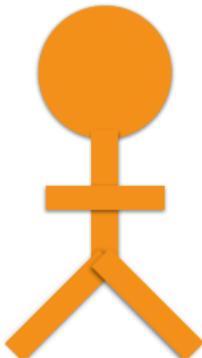
```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```



Lend the string
mutably

```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```

Take a **mutable**
reference to a String



Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```

Lend the string
mutably

```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```

Take a **mutable**
reference to a String



Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```



```
fn update(name: &mut String) {  
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}
```

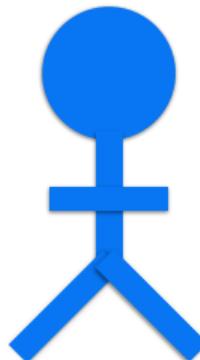
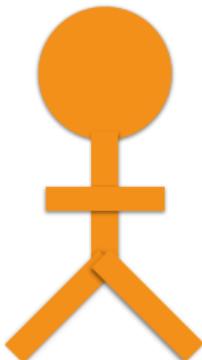


Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```

```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```

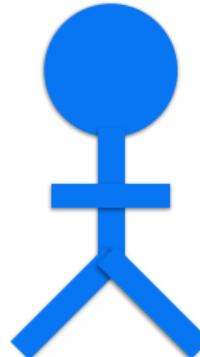
Mutate string
in place



Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```

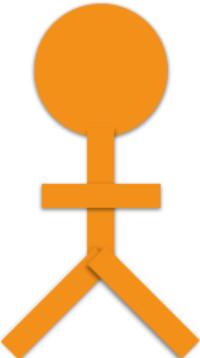
```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```



Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
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```

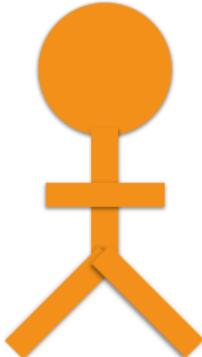
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}
```



Mutable borrow

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fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}
```

```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```



Mutable borrow

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fn main() {  
    let mut name = ...;  
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}
```

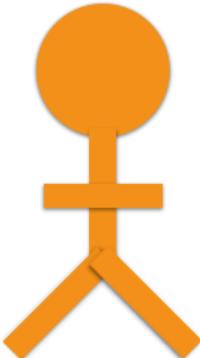
```
fn update(name: &mut String) {  
    name.push_str("...");  
}
```

Prints the
updated string.



Mutable borrow

```
fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}  
  
fn update(name: &mut String) {  
    name.push_str("...");  
}
```



Mutable borrow

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fn main() {  
    let mut name = ...;  
    update(&mut name);  
    println!("{}", name);  
}  
  
fn update(name: &mut String) {  
    name.push_str("...");  
}
```



Mutable borrow

`name: String`

Ownership:

control all access, will free when done

`name: &String`

Shared reference:

many readers, no writers

`name: &mut String`

Mutable reference:

no readers, one writer



`name: String`

Ownership:

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`name: String`

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→ `name: &String`

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Ownership:

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`name: &String`

Shared reference:

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`name: &mut String`

Mutable reference:

no readers, one writer

(Un)safe

How do we get safety?

How do we get safety?



```
fn main() {
    let r;
    {
        let name = format!("...");
        r = &name;
    }
    println!("{}", r);
}
```

```
fn main() {  
    let r;  
    {  
        let name = format!("...");  
        r = &name;  
    }  
    println!("{}", r);  
}
```

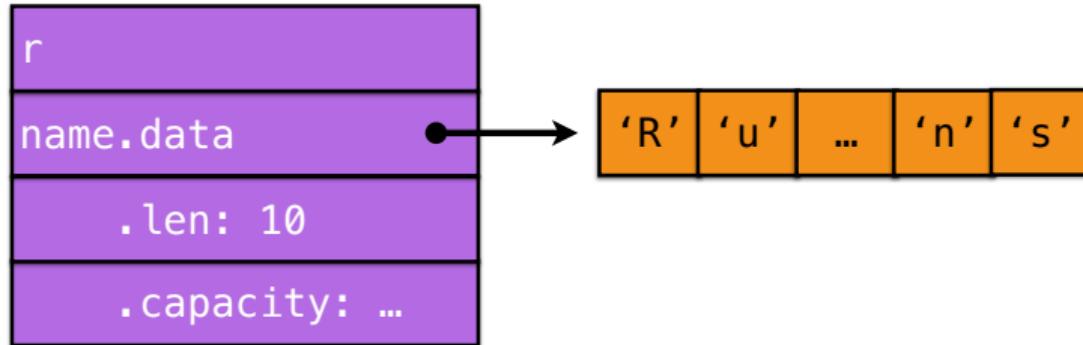
```
fn main() {  
    let r;  
    {  
        let name = format!("...");  
        r = &name;  
    }  
    println!("{}", r);  
}
```

r

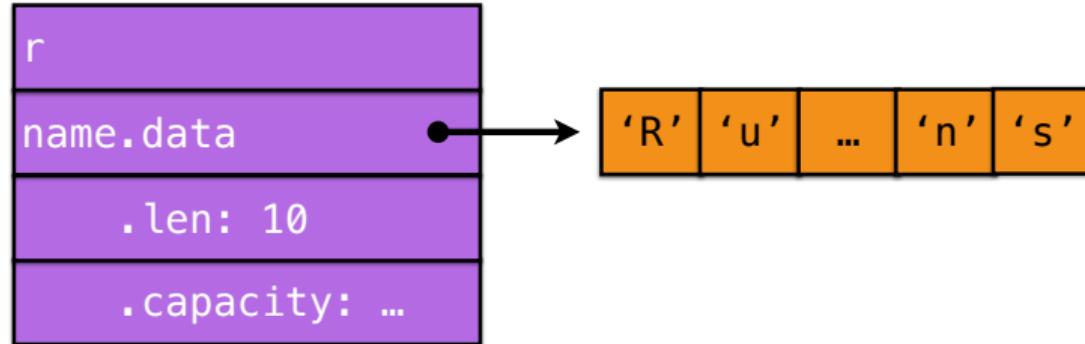
```
fn main() {  
    let r;  
    {  
        let name = format!("...");  
        r = &name;  
    }  
    println!("{}", r);  
}
```

r

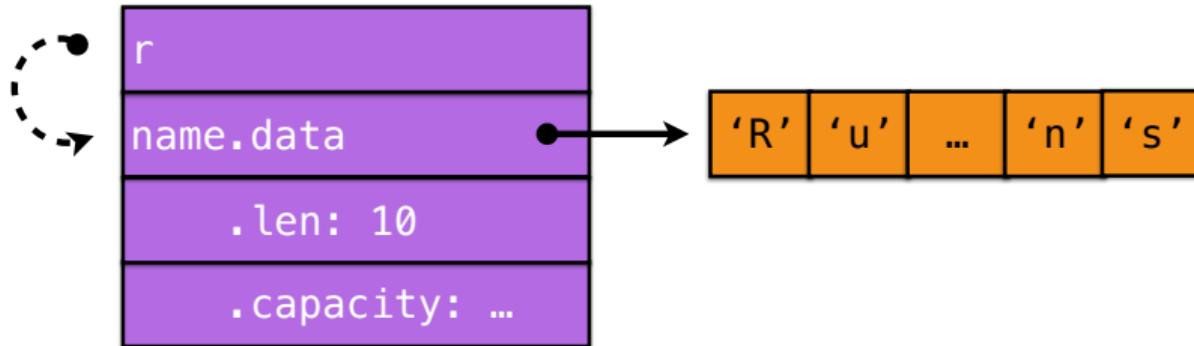
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fn main() {  
    let r;  
    {  
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        r = &name;  
    }  
    println!("{}", r);  
}
```



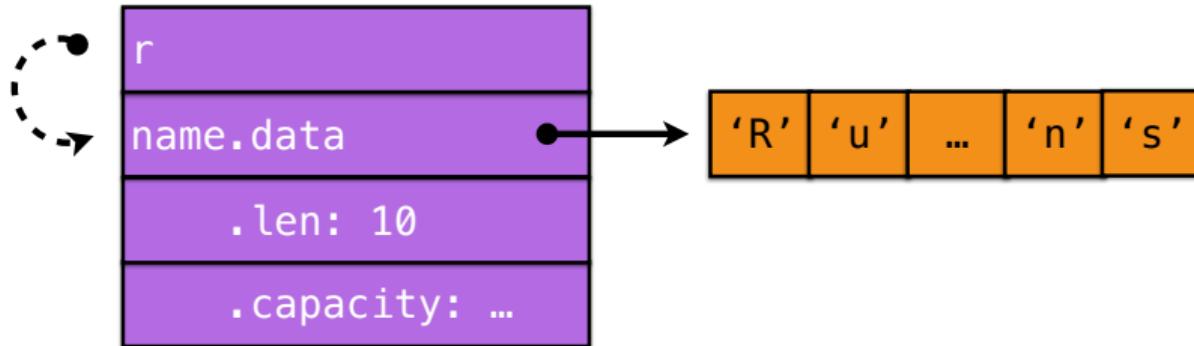
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    {  
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        r = &name;  
    }  
    println!("{}", r);  
}
```



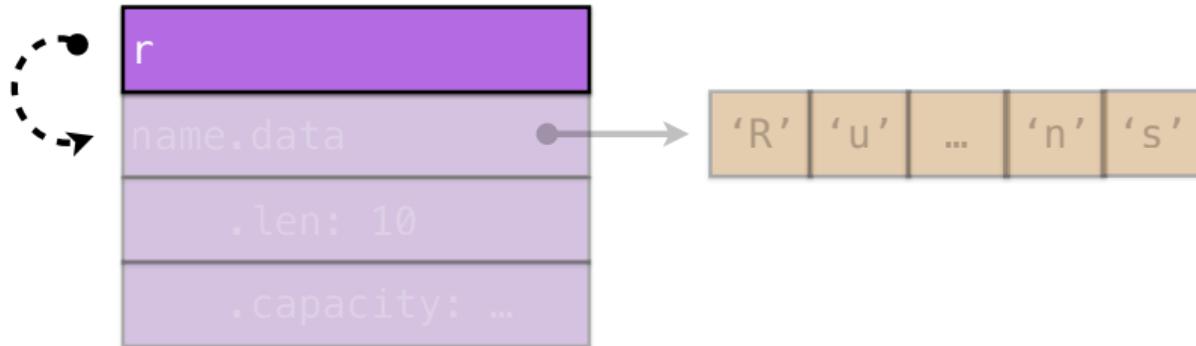
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}
```



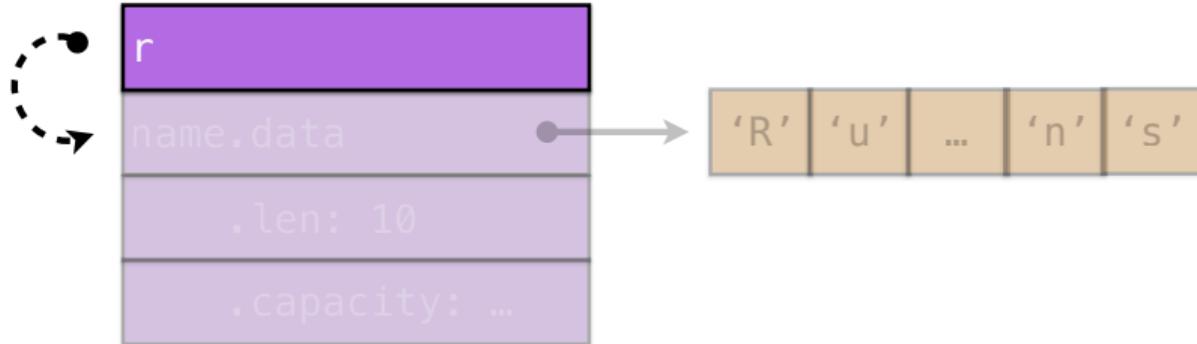
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```



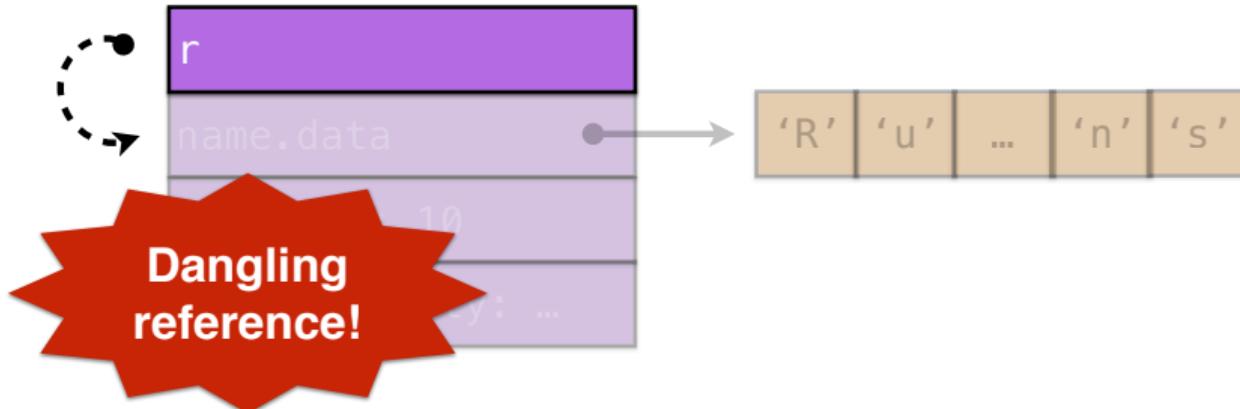
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    }
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}
```



```
fn main() {
    let r;
    {
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        r = &name;
    }
    println!("{}", r);
}
```



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```
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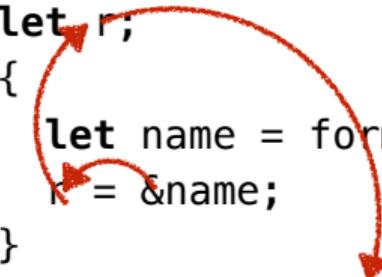
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fn main() {
    let r;
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        r = &name;
    }
    println!("{}", r);
}
```

Lifetime: span of code where reference is used.

```
fn main() {  
    let r;  
    {  
        let name = format!("...");  
        r = &name;  
    }  
    println!("{}", r);  
}
```

Lifetime: span of code where reference is used.

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}
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Lifetime: span of code where reference is used.

compared against

Scope of data being borrowed (here, `name`)

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fn main() {  
    let r;  
    {  
        let name = format!("...");  
        r = &name;  
    }  
    println!("{}", r);  
}
```

Lifetime: span of code where reference is used.

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Scope of data being borrowed (here, `name`)

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        r = &name;  
    }  
    println!("{}", r);  
}
```

Lifetime: span of code where reference is used.

compared against

Scope of data being borrowed (here, `name`)

```
error: `name` does not live long enough  
r = &name;  
     ^~~~
```

```
use std::thread;

fn helper(name: &String) {
    thread::spawn(move || {
        use(name);
    });
}
```

```
use std::thread;  
  
fn helper(name: &String) {  
    thread::spawn(move || {  
        use(name);  
    });  
}
```

name` can only be used within this fn



```
use std::thread;  
  
fn helper(name: &String) {  
    thread::spawn(move || {  
        use(name);  
    });  
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`name` can only be used within this fn

Might escape
the function!

```
use std::thread;  
  
fn helper(name: &String) {  
    thread::spawn(move || {  
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name` can only be used within this fn

Might escape
the function!

```
error: the type ` [...]` does not fulfill the required lifetime  
    thread::spawn(move || {  
        ^~~~~~  
note: type must outlive the static lifetime
```

```
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}
```

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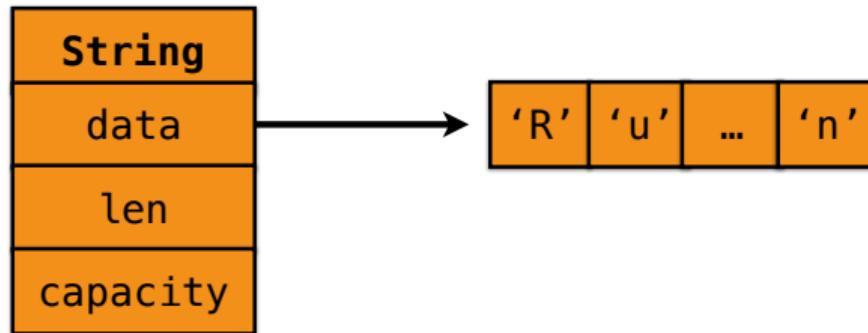
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error: the type ` [...]` does not fulfill the required lifetime  
    thread::spawn(move || {  
        ^~~~~~  
note: type must outlive the static lifetime
```

Dangers of mutation

```
let mut buffer: String = format!("Rustacean");
let slice = &buffer[1..];
buffer.push_str("s");
println!("{:?}", slice);
```

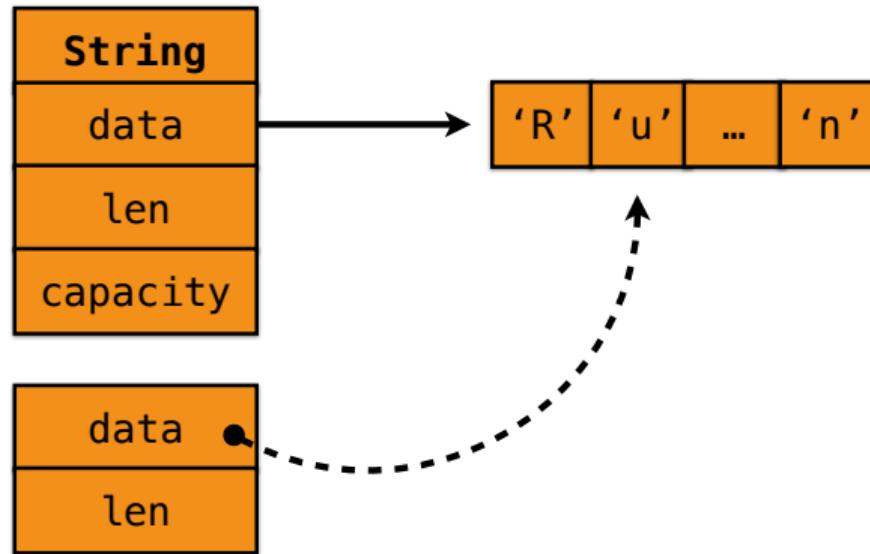
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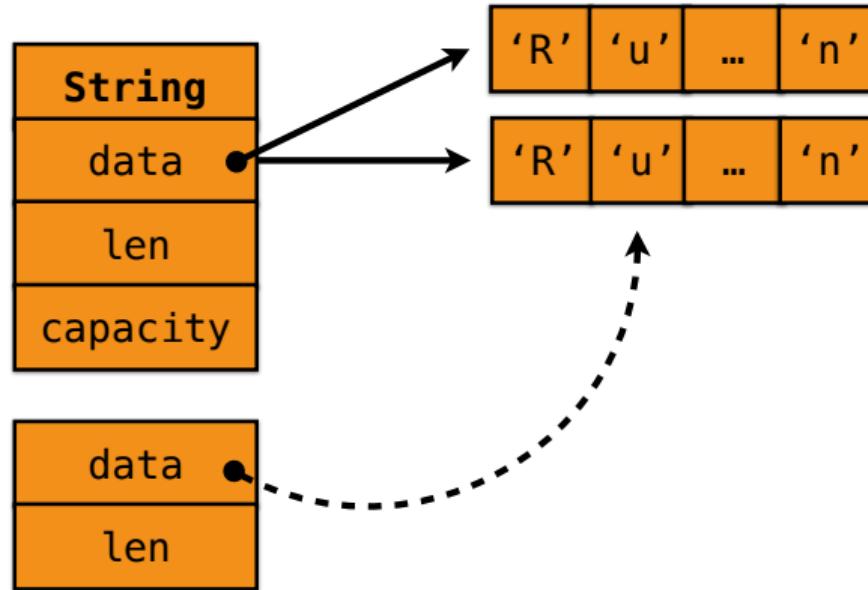
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let mut buffer: String = format!("Rustacean");
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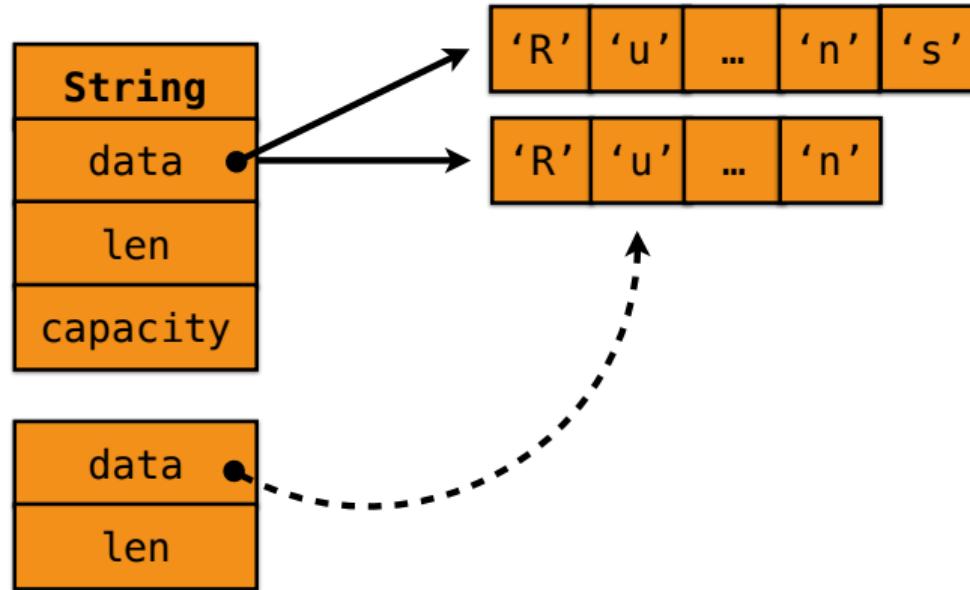
Dangers of mutation

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buffer.push_str("s");
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```



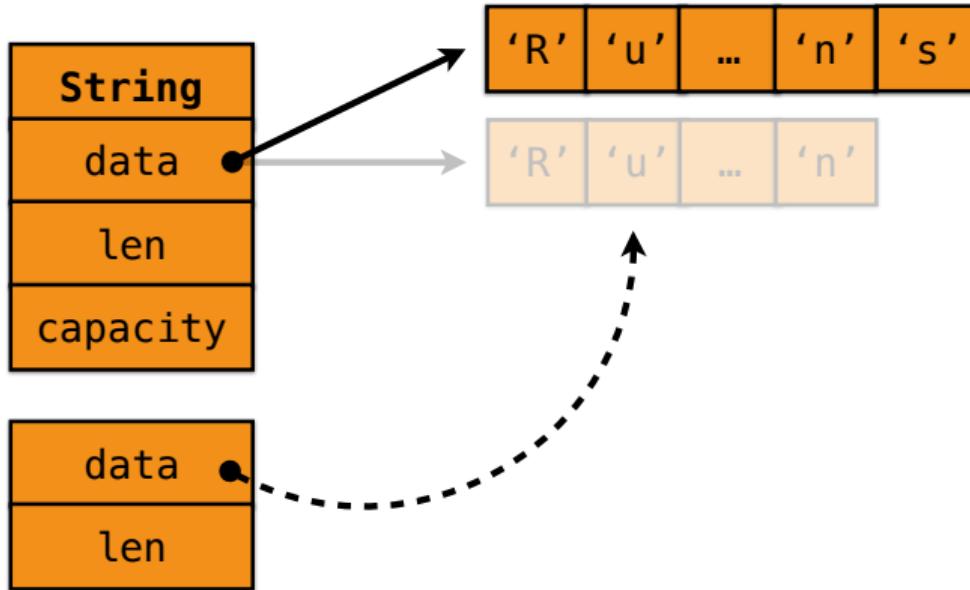
Dangers of mutation

```
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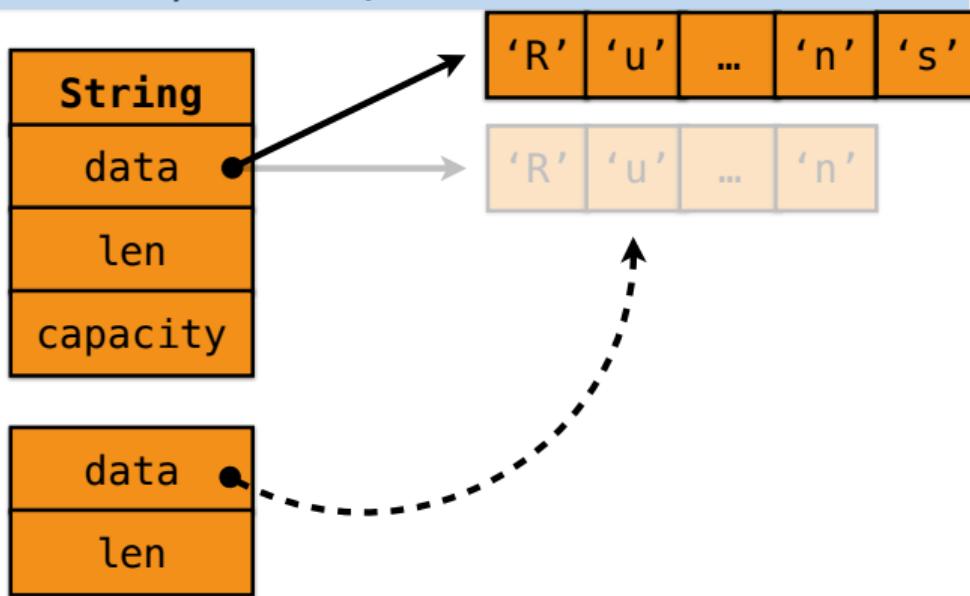
Dangers of mutation

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let slice = &buffer[1..];
buffer.push_str("s");
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```



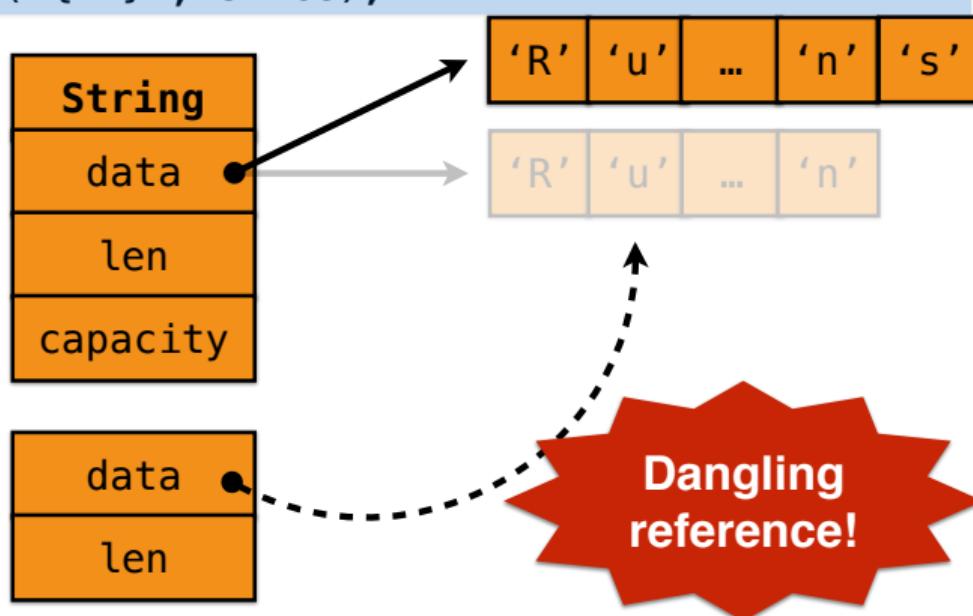
Dangers of mutation

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let slice = &buffer[1..];
buffer.push_str("s");
println!("{}:?", slice);
```



Dangers of mutation

```
let mut buffer: String = format!("Rustacean");
let slice = &buffer[1..];
buffer.push_str("s");
println!("{}:?", slice);
```



Rust solution

Compile-time read-write-lock:

Creating a shared reference to X “**read locks**” X.

- Other readers OK.
- No writers.
- Lock lasts until reference goes out of scope.

Creating a mutable reference to X “**writes locks**” X.

- No other readers or writers.
- Lock lasts until reference goes out of scope.

Never have a reader/writer at same time.

Dangers of mutation

```
fn main() {  
    let mut buffer: String = format!("Rustacean");  
    let slice = &buffer[1..];  
    buffer.push_str("s");  
    println!("{}:?", slice);  
}
```

Dangers of mutation

```
fn main() {  
    let mut buffer: String = format!("Rustacean");  
    let slice = &buffer[1..];  
    buffer.push_str("s");  
    println!("{}:?", slice);  
}
```



Borrow “locks”
`buffer` until `slice`
goes out of scope

Dangers of mutation

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Dangers of mutation

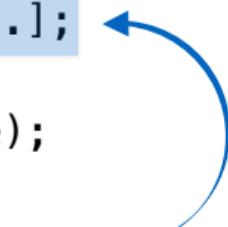
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}
```

Borrow “locks”
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goes out of scope

```
error: cannot borrow `buffer` as mutable  
      because it is also borrowed as immutable  
      buffer.push_str("s");  
      ^~~~~~
```

```
fn main() {
    let mut buffer: String = format!("Rustacean");
    for i in 0 .. buffer.len() {
        let slice = &buffer[i..];
        buffer.push_str("s");
        println!("{}:?", slice);
    }
    buffer.push_str("s");
}
```

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        buffer.push_str("s")  
        println!("{}:?", slice);  
    }  
    buffer.push_str("s");  
}
```

Borrow “locks”
`buffer` until `slice`
goes out of scope

OK: `buffer` is not borrowed here

(Un)safe

Comparison

C

```
1 uint8_t* pointer = (uint8_t*) malloc(SIZE); // Might return NULL
2 for(int i = 0; i < SIZE; ++i) {
3     pointer[i] = i; // Might cause a Segmentation Fault
4 }
```

Rust

```
1 let mut vec = vec![0 as u8; SIZE];
2 for i in 0..SIZE { // As C code
3     vec[i] = i;
4 }
```

Functional Rust

```
1 let vec: Vec<u8> = (0..10).collect();
```

Rust References

```
1 let my_var: u32 = 42;
2 let my_ref: &u32 = &my_var; // References ALWAYS point
3 // to valid data
4 let my_var2 = *my_ref; // An example for a Dereference
```

```
1  uint8_t* pointer = (uint8_t*) malloc(SIZE);
2  // ...
3  if (err) {
4      abort = 1;
5      free(pointer);
6  }
7  // ...
8  if (abort) {
9      logError("operation aborted", pointer);
10 }
```

Rust

```
1 let vec: Vec<u32> = Vec::new();
2 {
3     {
4         let vec_1 = vec; // vec's ownership has been moved
5     } // the Vec will be freed (dropped) here
6 }
```

```
1 uint8_t* get_dangling_pointer(void) {
2     uint8_t array[4] = {0};
3     return &array[0];
4 }
```

```
fn get_dangling_pointer() -> &u8 {  
    let array = [0; 4];  
    &array[0]  
}
```

Compile time error

```
1 | fn get_dangling_pointer() -> &u8 {  
| | ^ help: consider giving it a  
| | 'static lifetime: `&'static`  
| |  
= help: this function's return type contains a borrowed value,  
| | but there is no value for it to be borrowed from
```

```
1 void print_out_of_bounds(void) { C
2     uint8_t array[4] = {0};
3     printf("%u\r\n", array[4]);
4 }
5 // prints memory that's outside `array` (on the stack)
```

Rust

```
1 fn print_panics() {  
2     let array = [0; 4];  
3     println!("{}", array[4]);  
4 }
```

```
Compile time error  
error: index out of bounds: the len is 4 but the index is 4  
--> test.rs:8:20
```

```
|  
3 |     println!("{}", array[4]);  
|           ^^^^^^  
|  
|= note: #[deny(const_err)] on by default
```

(Un)safe

Concurrency

Originally: Rust had message passing built into the language

Now: library-based, multi-paradigm

- rayon (parallel processing, thread pool)
- tokio, futures (I/O, async)
- coroutine, coio (coroutine)
- crossbeam, mio (low-level concurrency)

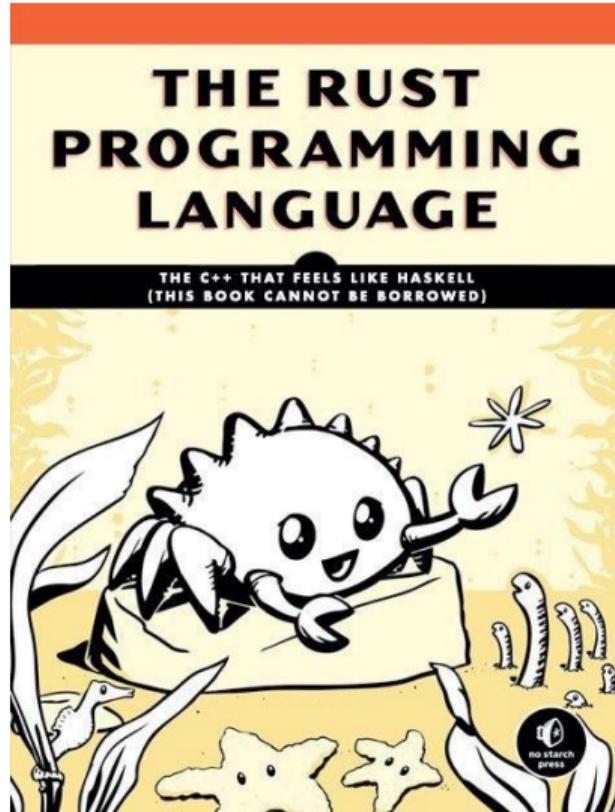
Libraries leverage **ownership and traits** to avoid data races



Rust

```
1 fn qsort(vec: &mut [i32]) {
2     if vec.len() <= 1 { return; }
3     let pivot = vec[random(vec.len())];
4     let mid = vec.partition(vec, pivot);
5     let (less, greater) = vec.split_at_mut(mid);
6
7     rayon::join(|| qsort(less),
8                 || qsort(greater));
9
10 }
```

Syntax



Syntax

Concepts

```
1 //! # Main
2 //! Module docs
3
4 /// Docs
5 // Comments
6 fn main() {
7     let x = 31337;
8     println!("The value of x is: {}", x); // 31337
9     let mut y: u8 = 5;
10    y = x as u8;
11    println!("The value of y is: {}", y); // 105
12 }
```

```
1 fn nsa(is_hack: bool, backdoor: &str, blue_pill: String) -> f64 {
2     for c in blue_pill.chars() {
3         print!("{}", c);
4     }
5     if is_hack {
6         loop { break 3.1337; }
7     } else if backdoor.len() > 3 {
8         42.0 - 42.0
9     } else {
10        3.14
11    }
12 }
```

Syntax

Enums (Algebraic data type)

```
1 enum Pohek {
2     XSS(XssType),
3     SocialEngineering,
4     Phishing,
5     // ...
6 }
7
8 enum XssType {
9     Reflected,
10    Stored,
11    // ...
12 }
```

```
1
2     match pohek {
3         Pohek::XSS(xss_type) =>
4             {
5                 hack_by_xss(xss_type);
6             },
7         Pohek::SocialEngineering |
8         Pohek::Phishing =>
9             {
10                 pa3Becmu_JIOXA();
11             }
12         - => { } ,
13     }
```

```
1 fn find_vulnerability(program: &Program) -> Option<Vulnerability>
2     ↪ { ... }
3
4 fn hack_program(program: &mut Program) {
5     match find_vulnerability(&program) {
6         Some(vuln) => {
7             exploit(vuln);
8         }
9     }
10 }
```

- std::optional
- std::variant
- std::any
- std::pair

```
error C2664: 'void
std::vector<block,std::allocator<_Ty>>::p
ush_back(const block &)': cannot convert
argument 1 from 'std::
_Vector_iterator<std::_Vector_val<std::
_Simple_types<block>>>' to 'block &&'
```



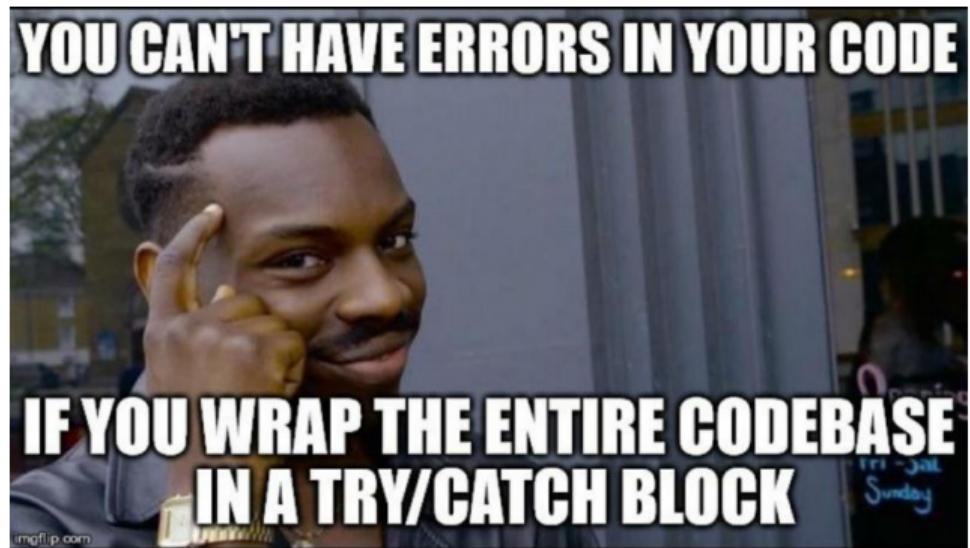
Syntax

Error handling

- Return code (C, Go)



- Return code (C, Go)
- Exceptions (C++, Python)



- Return code (C, Go)
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- Global variable (custom)

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- Return code (C, Go)
- Exceptions (C++, Python)
- Global variable (custom)
- Design by Contract (SPARK)
- Error (success) indicator (Haskell)

slaps roof of language standard
this bad boy can fit so much
undefined behavior in itx6²I2÷Pts}{I—iO>D@f—k—0_||2;j"—"æ



```
1 fn main() {  
2     let v = vec![1, 2, 3];  
3  
4     v[99];  
5 }
```

Output

```
1 thread 'main' panicked at 'index out of bounds: the len is 3 but
   ↳ the index is 99', /checkout/src/liballoc/vec.rs:1555:10
2 note: Run with `RUST_BACKTRACE=1` for a backtrace.
```

Output

```
1 ...
2 2: std::panicking::default_hook::{closure}
3     at /checkout/src/libstd/sys_common/backtrace.rs:60
4     at /checkout/src/libstd/panicking.rs:381
5 ...
6 11: panic::main
7     at src/main.rs:4
8 12: __rust_maybe_catch_panic
9     at /checkout/src/libpanic_unwind/lib.rs:99
10 13: std::rt::lang_start
11     at /checkout/src/libstd/panicking.rs:459
12     at /checkout/src/libstd/panic.rs:361
13     at /checkout/src/libstd/rt.rs:61
14 14: main
15 ...
```

```
1 enum Result<T, E> {
2     Ok(T),
3     Err(E),
4 }
```

```
1 pub fn hack_program(program: &Program) -> Result<Shell> { ... }
2
3 match hack_program(&program) {
4     Ok(shell) => connect(shell),
5     Err(error) => {
6         // Do something with error
7     }
8 }
```

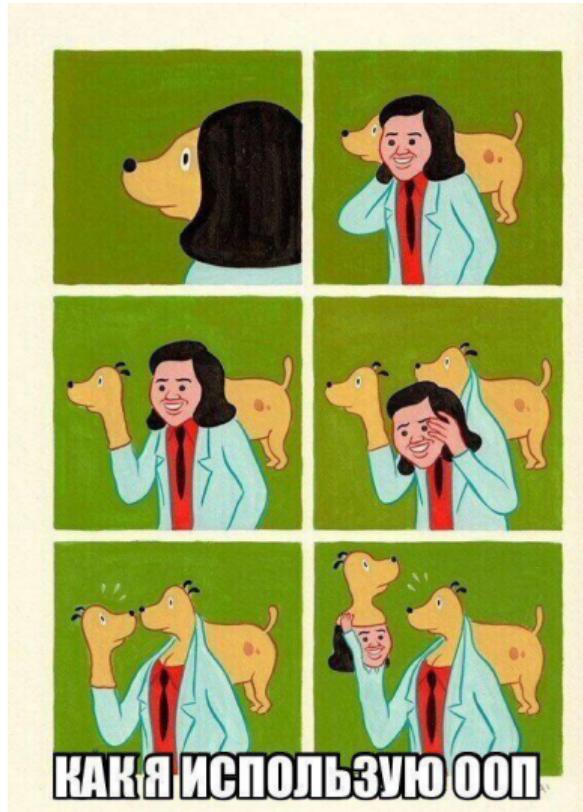
```
1 fn hack_world(world: World) -> Result<Power, u32> {
2     hack_program(&program)?;
3
4     for program in &world.programs() {
5         hack_program(program).map(install_spy).map(get_money)?;
6     }
7 }
```

Syntax

Structs



Проблемы при использовании ООП



```
1 struct Hacker {  
2     nickname: String,  
3     scope: Scope,  
4     cves: Vec<u32>,  
5 }  
6  
7 enum Scope {  
8     Fuzzing,  
9     Developing,  
10    Exploiting,  
11    Reversing,  
12 }
```

```
1  impl Hacker {  
2      fn new(nickname: String, scope: Scope) -> Hacker {  
3          Hacker {  
4              nickname: nickname,  
5              scope: scope,  
6              cves: Vec::new(),  
7          }  
8      }  
9  }
```

```
1 impl Hacker {  
2     fn new(nickname: String, scope: Scope) -> Self {  
3         Hacker {  
4             nickname, scope,  
5             cves: Vec::new(),  
6         }  
7     }  
8 }
```

```
1 impl Hacker {
2     fn add_cve(&mut self, cve: u32) {
3         self.cves.push(cve);
4     }
5     fn cves(&self) -> &Vec<u32> {
6         &self.cves
7     }
8 }
```

Syntax

Other

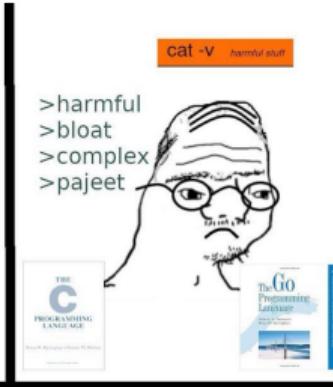
- Generics



- Generics
- Traits
 - as interfaces
 - for code reuse
 - for operator overloading
- Trait objects

Traits Polymorphism Generics Concepts

	innatezuuk	set: added constructor for set with a size hint
■	b16set	set: added constructor for set with a size hint
■	b32set	set: added constructor for set with a size hint
■	b64set	set: added constructor for set with a size hint
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■	i64set	set: added constructor for set with a size hint
■	internalset	set: added constructor for set with a size hint
■	iset	set: added constructor for set with a size hint
■	s32set	set: added constructor for set with a size hint
■	s64set	set: added constructor for set with a size hint
■	us32set	set: added constructor for set with a size hint
■	us64set	set: added constructor for set with a size hint
■	uiset	set: added constructor for set with a size hint
■	uset	set: added constructor for set with a size hint



>simple
>beautiful
>minimal



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- Closures (`|x| 2 * x`)

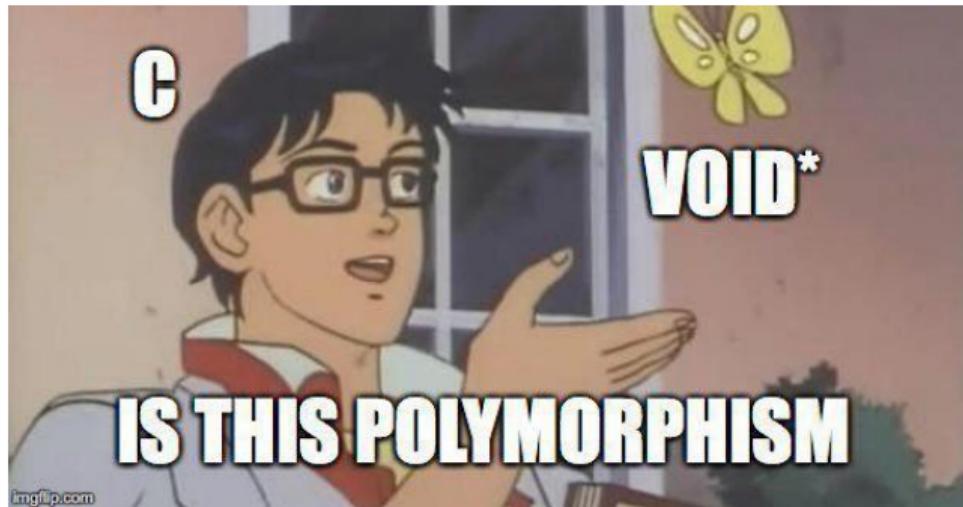
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- Closures (`|x| 2 * x`)
- Common collections
- Smart pointers

SMART POINTERS

RAW POINTERS

RAW POINTERS TO SMART POINTERS

- Generics
- Traits
 - as interfaces
 - for code reuse
 - for operator overloading
- Trait objects
- Closures (`|x| 2 * x`)
- Common collections
- Smart pointers
- Polymorphism, encapsulation
- ...



Ecosystem

A faint, light-gray network graph serves as the background for the entire slide. It consists of numerous small, semi-transparent gray dots representing nodes, connected by thin gray lines representing edges. The graph is highly interconnected, forming a complex web-like pattern across the entire frame.

Ecosystem

Community

- Rust Working Groups
 - Networking services
 - WebAssembly
 - CLI Apps
 - Embedded Devices
 - Lang and compiler working groups (WG-NLL, WG-UCG, WG-Traits and etc)



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- Blogs (Official, Read Rust, Core Developers, many others)



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Ecosystem

Cargo

Best package manager!

- Create structure of project
- Check and update dependencies
- Check, build and compile project
- Search and install packages
- Compile and run examples
- Generate docs
- Compile and run tests (in docs too)
- Compile and run benchmarks
- etc



Ecosystem

Additional tools

Cargo plugins

- cargo-asm
- cargo-call-stack
- cargo-clippy
- cargo-fmt
- cargo-fuzz
- cargo-geiger
- cargo-graph
- cargo-install-update
- cargo-llvm-ir
- cargo-profdata
- cargo-size
- many others!

- Rust documentation
- Crates.io – all packages
- Docs.rs – all documentation
- Rust book



Ecosystem

Rustup

Rustup install

```
$ curl https://sh.rustup.rs -sSf | sh
```

Toolchain format

<channel> [<date>] [<host>]

<channel> = stable|beta|nightly|<version>

<date> = YYYY-MM-DD

<host> = <target-triple>

Install nightly toolchain

\$ rustup toolchain install nightly

Cross compile

```
$ rustup target add mips64el-unknown-linux-gnuabi64  
$ cargo build --target=mips64el-unknown-linux-gnuabi64
```

- aarch64-apple-ios
- aarch64-fuchsia
- arm-unknown-linux-gnueabihf
- armv5te-unknown-linux-musleabi
- asmjs-unknown-emscripten
- i686-pc-windows-msvc
- powerpc-unknown-linux-gnu
- riscv32imac-unknown-none-elf
- sparcv9-sun-solaris
- wasm32-unknown-emscripten
- x86_64-unknown-redox
- ...

Ecosystem

Rust in production

Hundreds of companies around the world are using Rust in production today for fast, low-resource, cross-platform solutions

- Mozilla
- Cloudflare
- Microsoft
- CoreOS, Inc.
- The GNOME Project
- Coursera
- OVH
- Sourcegraph
- Google
- npm, Inc.
- Amazon
- Parity
- System 76
- Canonical
- ThreatX
- Wire
- Samsung
- Dropbox
- Discord
- Atlassian
- Baidu
- Fortanix
- Figma
- many others

Popularity

Popularity

Popular software

- CLI tools
- Web
- Servo

Experience and Pitfalls

Experience and Pitfalls

Compile time errors

Experience and Pitfalls

Compilation times

Experience and Pitfalls

Complex syntax

Experience and Pitfalls

Learning curve

Experience and Pitfalls

Format of errors

Summary

Questions?

