A Friendly Introduction to Rust For C++ Developers

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Link to Slides:

https://github.com/hniemeyer/RustForCppDevs

Feedback and Questions

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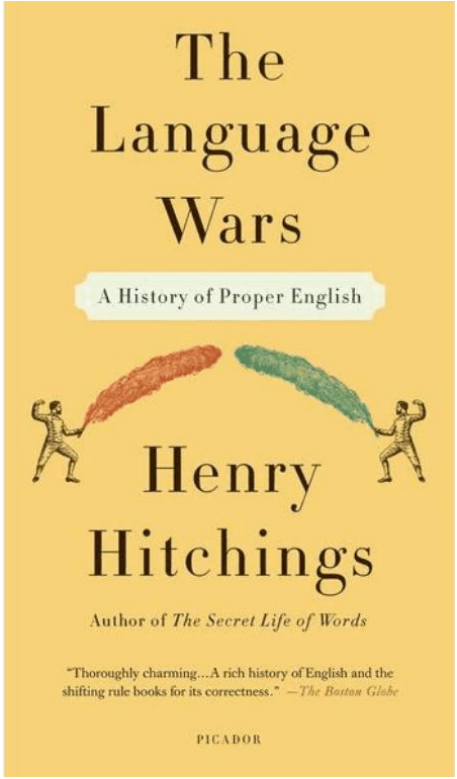
Disclaimer


The Language Wars
A History of Proper English
Henry Hitchings
Author of The Secret Life of Words
"Thoroughly charming…A rich history of English and the shifting rule books for its correctness." —The Boston Globe
PICADOR

If you want to try out code

- Compiler Explorer supports Rust
- Rust Playgound

Motivation

```
int main()
{
    std::vector<int> v({-7,1,2,3});
    int& x = v[0];
    v.push_back(12);
    std::cout << "The number is: " << x;
}
```

```
The number is: 0
```

https://gcc.godbolt.org/z/8Mao4T

Motivation

```
error[E0502]: cannot borrow `v` as mutable because it is also borrowed as immutable
 --> <source>:4:5
  |
3 |     let x = &v[0];
  |             - immutable borrow occurs here
4 |     v.push(12);
  |     ^^^^^^^^^^ mutable borrow occurs here
5 |     println!("The number is: {}", x);
  |                                   - immutable borrow later used here
```

Motivation

RustConf 2020 - Opening Keynote

What is Rust?

Why Rust?

Performance

Rust is blazingly fast and memory-efficient: with no runtime or garbage collector, it can power performance-critical services, run on embedded devices, and easily integrate with other languages.

Reliability

Rust's rich type system and ownership model guarantee memory-safety and thread-safety — enabling you to eliminate many classes of bugs at compile-time.

Productivity

Rust has great documentation, a friendly compiler with useful error messages, and top-notch tooling — an integrated package manager and build tool, smart multi-editor support with auto-completion and type inspections, an auto-formatter, and more.

Syntax and Mutability

```rust
fn add(x: i32, y: i32) -> i32
{ x+y }

fn main() {
    let a = 5;
    let b = 10;
    let mut res = add(a,b);
    res += 5;
    println!("The result is
{}", res);
}
```

```cpp
int add(int x, int y)
{ return x + y; }

int main() {
  const auto a = 5;
  const auto b = 10;
  auto res = add(a, b);
  res += 5;
  std::cout << "The result is
" << res;
}
```

const in Rust

```rust
const fn fib(n: i32) -> i32 {
    if n < 2 { 1 }
    else { fib(n-1) + fib(n-2) }
}

fn main() {
    let x = fib(5);
    const S: i32 = fib(8);
    println!("{}", x);
    println!("{}", S);
}
```

```cpp
constexpr int fib(int n) {
  if (n < 2)
    return 1;
  else
    return fib(n - 1) + fib(n - 2);
}

int main() {
  const auto x = fib(5);
  constexpr auto S = fib(8);
  std::cout << x << '\n';
  std::cout << S << '\n';
}
```

Variables and References

- Each value in Rust has a variable that’s called its owner
- There can only be one owner at a time
- When the owner goes out of scope, the value will be dropped
- At any given time, you can have either one mutable reference or any number of immutable references but not both
- References must always be valid

References

```
let mut s = String::from("hello");

let r1 = &s; // no problem
let r2 = &s; // no problem
let r3 = &mut s; // BIG PROBLEM

println!("{}, {}, and {}", r1, r2, r3);
```

References

```
let mut s = String::from("hello");

let r1 = &s; // no problem
let r2 = &s; // no problem
println!("{} and {}", r1, r2);
// r1 and r2 are no longer used after this point

let r3 = &mut s; // no problem
println!("{}", r3);
```

Dangling References

```
fn main() {
    let reference_to_nothing = dangle();
}

fn dangle() -> &String {
    let s = String::from("hello");

    &s
}
```

```
this function's return type contains a borrowed value, but there is no value
for it to be borrowed from.
```

Are there any questions?

Copy Semantics

```
fn main() {
    let a = 5;
    let b = a;
    println!("The result is {}", a);
}
```

Move Semantics II

```
struct WrappedNumber {
    value: i32
}

fn main() {
    let a = WrappedNumber {value: 5};
    let b = a;
    println!("The result is {}", a.value);
}
```

Move Semantics III

```
error[E0382]: borrow of moved value: `a`
 --> src/main.rs:8:34
  |
6 |     let a = WrappedNumber {value: 5};
  |         - move occurs because `a` has type `WrappedNumber`, which does not implement the `Copy` trait
7 |     let b = a;
  |             - value moved here
8 |     println!("The result is {}", a.value);
  |                                  ^^^^^^^ value borrowed here after move
```

Expressions

```
fn main() {
    let x = 12;
    let number = if x < 11 { 5 } else { 6 };
    let mut counter = 0;
    let result = loop {
        counter += number;
        if counter> 3*x {
            break counter * x;
        }
    };
    println!("The value of number is: {}", number);
    println!("The value of result is {}", result);
}
```

Are there any questions?

Structs

```
struct Square {
    length: f32
}

fn main() {
    let a = Square {length: 5.2};
    println!("My square is {} long!", a.length);
}
```

Methods

```
impl Square {

    fn area(&self) -> f32 {
        self.length * self.length
    }


    fn grow(&mut self, factor: f32) {
        self.length *= factor;

    }
}
```

Methods

```
impl Square {
    fn new(l: i32) -> Self {
        Self {length: l}
    }
}

fn main() {
    let my_square = Square::new(3);
    println!("{}",my_square.length)
}
```

Vector

```
fn main() {
    let mut my_vec = Vec::new();
    my_vec.push(8);

    let mut my_other_vec = vec![1,2,3];

    for i in &mut my_other_vec {
        *i += 2;
    }

    let sum: i32 = my_other_vec.iter().sum();
    println!("{}", sum);
}
```

Traits

```
trait Shape {
    fn area(&self) -> f32;
}

impl Shape for Square {
    fn area(&self) -> f32 {
        self.length * self.length
    }
}

fn print_area(shape: &impl Shape) {
    println!("The area is {}", shape.area());
}
```

Generics and Trait Bounds

```
fn print_area<T: Shape>(shape: &T) {
    println!("The area is {}", shape.area());
}

fn print_area<T: Shape + Density>(shape: &T) {
}

fn some_function<T, U>(t: &T, u: &U) -> i32
    where T: Display + Clone,
          U: Clone + Debug
{ }
```

Derivable Traits

```
#[derive(Clone, Copy)]
struct Rectangle {
    width: u32,
    height: u32,
}

fn main() {
    let a = Rectangle {width: 5, height: 3};
    let b = a;
    println!("{}", a.width);
    println!("{}", b.width);
}
```

Tuple-like Structs

```
struct Color(i32, i32, i32);
struct Point(i32, i32, i32);

fn main() {
    let black = Color(0, 0, 0);
    let origin = Point(0, 0, 0);
    let my_tuple = (1,2,3);
    let (x, _, _) = my_tuple;
    let Color (r,g,b) = black;
    println!("{} {} {}", r, g, b);
    println!("{} {}", origin.1, x);
}
```

Are there any questions?

Enums

```
enum Action {
    Stay,
    Move {x: i32, y: i32},
    Fight(i32),
    Say(String),
}

fn main() {
    let my_action = Action::Move {x: 12, y: 15};
}
```

Pattern Matching

```
fn main() {
    let my_action = Action::Move {x: 12, y: 15};
    let result = match my_action {
        Action::Stay => 5,
        Action::Move {x, y} => {println!("Moving");
                                x+y},
        _ => 20
    };
    println!("{}", result);
}
```

if let

```
fn main() {
    let my_action = Action::Move {x: 12, y: 15};
    let result = if let Action::Move {x,y} = my_action {  x+y }
    else {
       5
    };
    println!("{}", result);
}
```

Option

```
enum Option<T> {
    Some(T),
    None,
} //defined by standard lib

let some_number = Some(5);
let absent_number: Option<i32> = None;
```

Error Handling

```
use std::fs::File;

enum Result<T, E> {
    Ok(T),
    Err(E),
}

fn main() {
    let f = File::open("hello.txt");

    let f = match f {
        Ok(file) => file,
        Err(error) => panic!("Problem opening the file: {:?}", error),
    };
}
```

Error Handling

```
use std::fs::File;

fn main() {
    let f = File::open("hello.txt").unwrap();
    let g = File::open("world.txt").expect("Failed to open
world.txt");
}
```

Error Handling: The ? operator

```
fn read_file() -> Result<File, io::Error> {
    let f = File::open("hello.txt");

    let f = match f {
        Ok(file) => file,
        Err(e) => return Err(e),
    };
    Ok(f)
}

fn main() {
    let my_file = read_file().unwrap();
}
```

Error Handling: The ? operator

```
use std::fs::File;
use std::io;

fn read_file() -> Result<File, io::Error> {
    let f = File::open("hello.txt")?;
    Ok(f)
}

fn main() {
    let my_file = read_file().unwrap();
}
```

Are there any questions?

Iterators

```
struct EvenNumbers {
    value: u32,
}

impl EvenNumbers {
    fn new() -> Self {
        Self { value: 2 }
    }
}

impl Iterator for EvenNumbers {
    type Item = u32;

    fn next(&mut self) -> Option<Self::Item> {
       let old_value = Some(self.value);
       self.value += 2;
       old_value
    }
}
```

Iterators

```
fn main() {
    let my_series = EvenNumbers::new();
    let result: u32 = my_series.skip(5).map(|x| x*x).take(10).sum();
    println!("{}", result);
}
```

Tooling: Cargo

https://github.com/hniemeyer/rust_tooling_demo

Are there any questions?

Interop with C++

- Rust ist cool but shall we rewrite our 1.5 million LOC C++ codebase in Rust?
- of course not
- Maybe new projects in Rust.
- what options do we have for interop are there?
- rust-bindgen (unsafe bindings, ffi)
- cxx crate (safe bindings, ffi)
- grpc (rpc) or Thrift (rpc)

Resources to Learn Rust

- Rust Book
- Rust Cookbook
- Rust by Example
- https://jrvidal.github.io/explaine.rs/

Are there any questions?

Feedback and Questions

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- Cpp Usergroup Osnabrück