

Why Is Rust the Rising Star?

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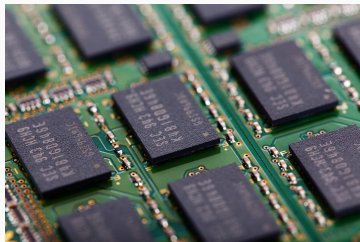
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Brno University of Technology

Why Rust Matters?

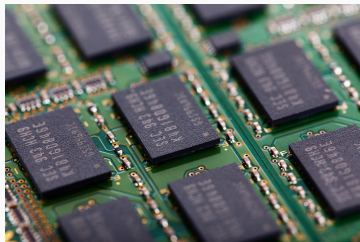
Why Rust Matters?

- Memory Safe Programming Language



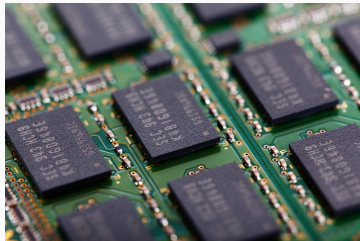
Why Rust Matters?

- Memory Safe Programming Language
- Performance Comparable to C and C++



Why Rust Matters?

- Memory Safe Programming Language
- Performance Comparable to C and C++
- Low-Level Control

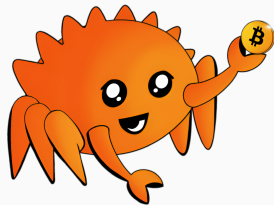


Stay Safe!



Where Can I Use Rust?

- Systems Programming & CLI Tools
- Concurrency and Parallelism
- Network Programming
- Embedded Systems
- Game Development
- High-Performance Computing
- Blockchain and Cryptography



- **National Security Agency (USA) urges shift to memory safe programming languages**
 - Published: Nov 12, 2022
- **Why Rust is one of the world's most cherished programming languages**
 - Published: Feb 26, 2024
- **White House urges developers to dump C and C++**
 - Published: Feb 27, 2024
- **Why Rust is emerging as developers' favourite programming language**
 - Published: May 28, 2024

We Want the Safety



We Want the Safety



What Is Rust?

What Is Rust?

- Safety, Speed, and Concurrency
- Developed by Mozilla (Graydon Hoare)
- First Stable Release in 2015
- Now an Open-Source Project with an Active Community
- Extensive Documentation, Tutorials, and Tools

What Do We Mean by **Safe**?

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Does It Mean That Rust Is **100%** Memory Safe?

What Is Rust?

What Do We Mean by **Safe**?

Does It Mean That Rust Is **100%** Memory Safe?

What Is the Reality of **Performance**?

Memory Safety

Memory Safety — C++ Example

C++

```
void addBeer(std::vector<int>& beers) {  
    beers.push_back(0); // Potential buffer overflow if vector was manually managed!  
}  
  
int main() {  
    int* beerFridge = new int[5]; // Yeah, new fridge!  
    delete[] beerFridge; // Throw away the scrap!  
    std::cout << beerFridge[0]; // Use-after-free.  
  
    std::vector<int> beerCollection(5);  
    addBeer(beerCollection); // Add another beer.  
  
    int* lostBeer = new int(42); // A lovely special beer.  
    // Forgot to delete lostBeer, potential memory leak here!  
  
    return 0; // Potential memory leak due to lostBeer!  
}
```

Memory Safety — Rust Example

Rust

```
fn add_beer(beers: &mut Vec<i32>) {  
    beers.push(0); // Safe, Rust's Vec handles resizing.  
}  
  
fn main() {  
    let beer_fridge = vec![0; 5]; // A new fridge.  
    drop(beer_fridge); // Throw it away!  
  
    // println!("{}", beer_fridge[0]); // Leads to compile-time error.  
  
    let mut beer_collection = vec![0; 5];  
    add_beer(&mut beer_collection); // Rust's borrowing.  
  
    let lost_beer = Box::new(42); // Special beer.  
    // Automatically deallocated when it goes out of scope.  
  
    // No manual management needed.  
}
```

Type System

C++

```
// Base class representing a dessert.  
class Dessert {  
public:  
    virtual ~Dessert() = default; // Destructor allowing polymorphic behavior and memory  
        management.  
    virtual double yumminess() const = 0; // Pure virtual function, making Dessert an abstract  
        base class.  
};
```

Type System — C++ Example

C++

```
int main() {  
    // The use of unique pointers (std::unique_ptr).  
    std::vector<std::unique_ptr<Dessert>> desserts;  
    desserts.push_back(std::make_unique<Cake>(5.0)); // Sweet cake!  
    desserts.push_back(std::make_unique<Cookie>(4.0, 6.0)); // Crunchy cookie with lots of  
        choco chips!  
  
    // ...  
  
    // Accessing memory after deallocation.  
    Cake* danglingPointer = dynamic_cast<Cake*>(desserts[0].get());  
    desserts.clear(); // Deallocate memory.  
  
    // Attempt to access memory through the dangling pointer.  
    danglingPointer->candleCount(); // Implemented only for cakes.  
  
    return 0;  
}
```

Rust

```
// Define an enum representing different types of desserts.  
enum Dessert {  
    // Cake dessert with sweetness as a parameter.  
    Cake { sweetness: f64 },  
    // Cookie dessert with crunchiness and choco_chips as parameters.  
    Cookie { crunchiness: f64, choco_chips: f64 },  
}
```

Type System — Rust Example

Rust

```
impl Dessert {  
    // Method to calculate the yumminess of the dessert.  
    fn yumminess(&self) -> f64 {  
        match self {  
            // Match on the enum variant to calculate yumminess based on dessert type.  
            Dessert::Cake { sweetness } => *sweetness * 1.5,  
            Dessert::Cookie { crunchiness, choco_chips } => crunchiness * 2.0  
                + choco_chips * 3.0,  
        }  
    }  
}
```

Type System — Rust Example

Rust

```
// Create a vector of desserts containing Cake and Cookie instances.
fn main() {
    let desserts = vec![
        Dessert::Cake { sweetness: 5.0 },
        Dessert::Cookie { crunchiness: 4.0, choco_chips: 6.0 },
    ];

    // ...

    // Rust's ownership system prevents access to dangling pointers.
}
```


Fixed!



Unsafe Rust

Unsafe Rust — C++ Example

C++

```
int main() {  
    int donuts[] = {1, 2, 3, 4, 5}; // Mmm... donuts!  
    int* bart = donuts; // Bart's pointer to the donuts.  
  
    std::cout << "Ay_caramba!" << std::endl;  
  
    for (int i = 0; i < 5; ++i) { // Bart's prank - doubling the donuts!  
        // No bounds checking.  
        *(bart + i) = *(bart + i) * 2; // Unsafe pointer arithmetic.  
    }  
  
    std::cout << "Uh_oh!_Bart's_modified_donuts:_";  
    for (int i = 0; i < 5; ++i) {  
        std::cout << donuts[i] << "_";  
    }  
    std::cout << "Woo-hoo!" << std::endl;  
  
    return 0;  
}
```

Unsafe Rust — Rust Example

Rust

```
fn main() {  
    let mut donuts = [1, 2, 3, 4, 5];  
    let bart = donuts.as_mut_ptr(); // Bart's pointer to the donuts.  
  
    println!("Ay_caramba!");  
  
    unsafe {  
        for i in 0..5 { // Bart's prank - doubling the donuts!  
            // No bounds checking.  
            *bart.add(i) *= 2; // Unsafe pointer arithmetic.  
        }  
    }  
  
    print!("Uh_oh!_Bart's_modified_donuts:");  
    for i in 0..5 {  
        print!("{}", donuts[i]);  
    }  
    println!("Woo-hoo!");  
}
```

Performance

Performance

- The Benchmarks Game (<https://bit.ly/3X4NLGI>)

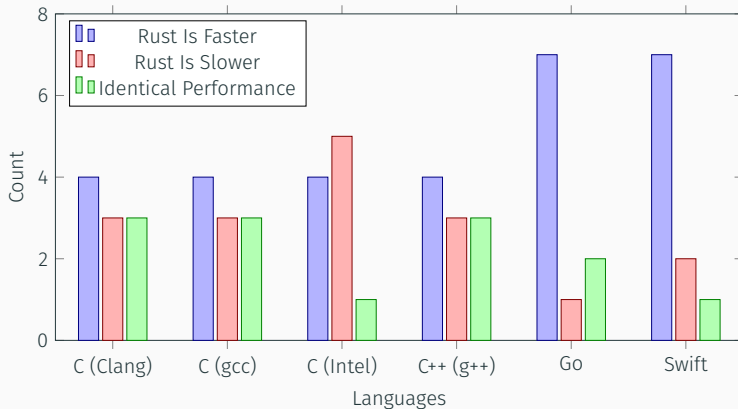


Figure 1: Comparison of Rust Performance with Other Languages

Presentation Hosted on GitHub

- The Presentation and Source Codes Available on:

<https://bit.ly/3KsMh1y>



Coding in Rust Is Hard ...



But It Makes Sense!



Why Is Rust the Rising Star?

Questions?

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