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Why Is Rust the Rising Star?

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Why Rust Matters?

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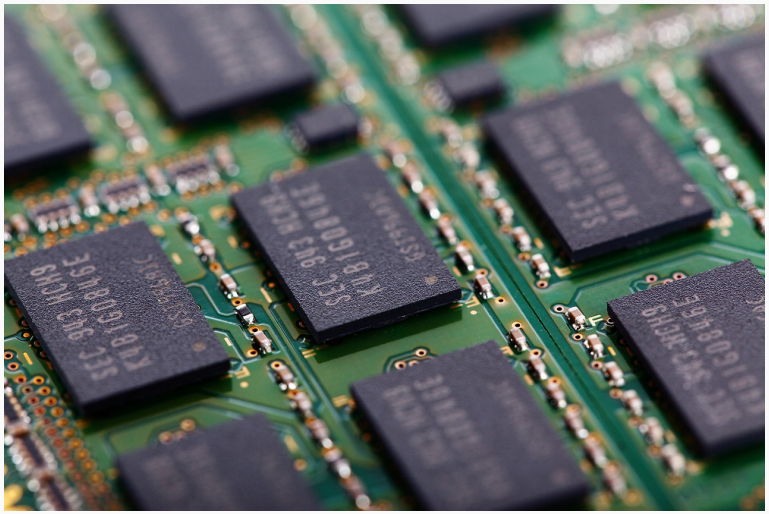
- Memory Safe Programming Language



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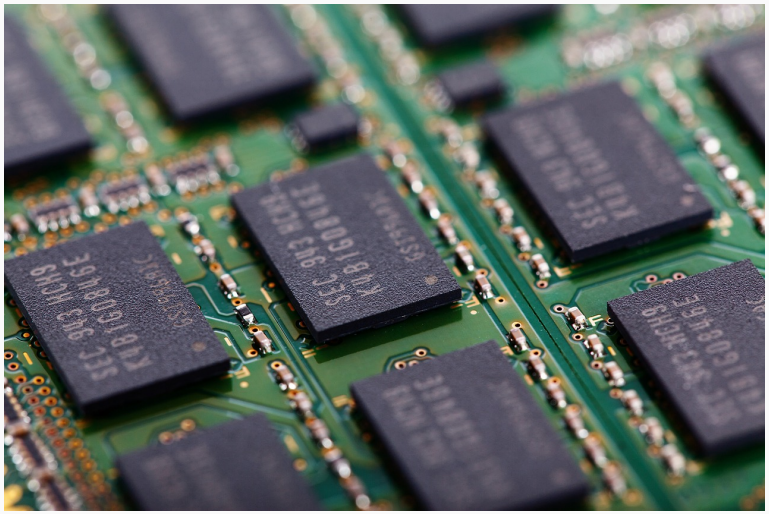
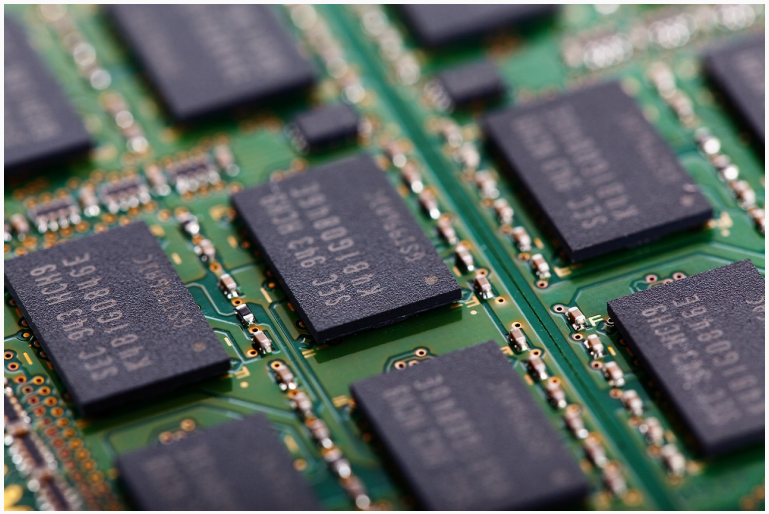
- Memory Safe Programming Language
- Performance Comparable to C and C++



Why Rust Matters?

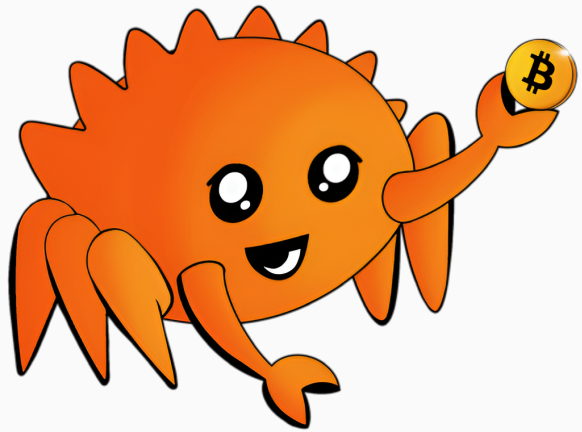
- Memory Safe Programming Language
- Performance Comparable to C and C++
- Low-Level Control



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



Rust in the News

- 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**?

What Is Rust?

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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++

```cpp
void addBeer(std::vector<int>& beers) {
    beers.push_back(10);  // 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 10 more beers.

    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

```rust
fn add_beer(beers: &mut Vec<i32>) {
    beers.push(10);  // 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

Type System — C++ Example

C++

```cpp
// 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++

```cpp
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;
}
```

Type System — Rust Example

Rust

```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

```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

```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

```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*)

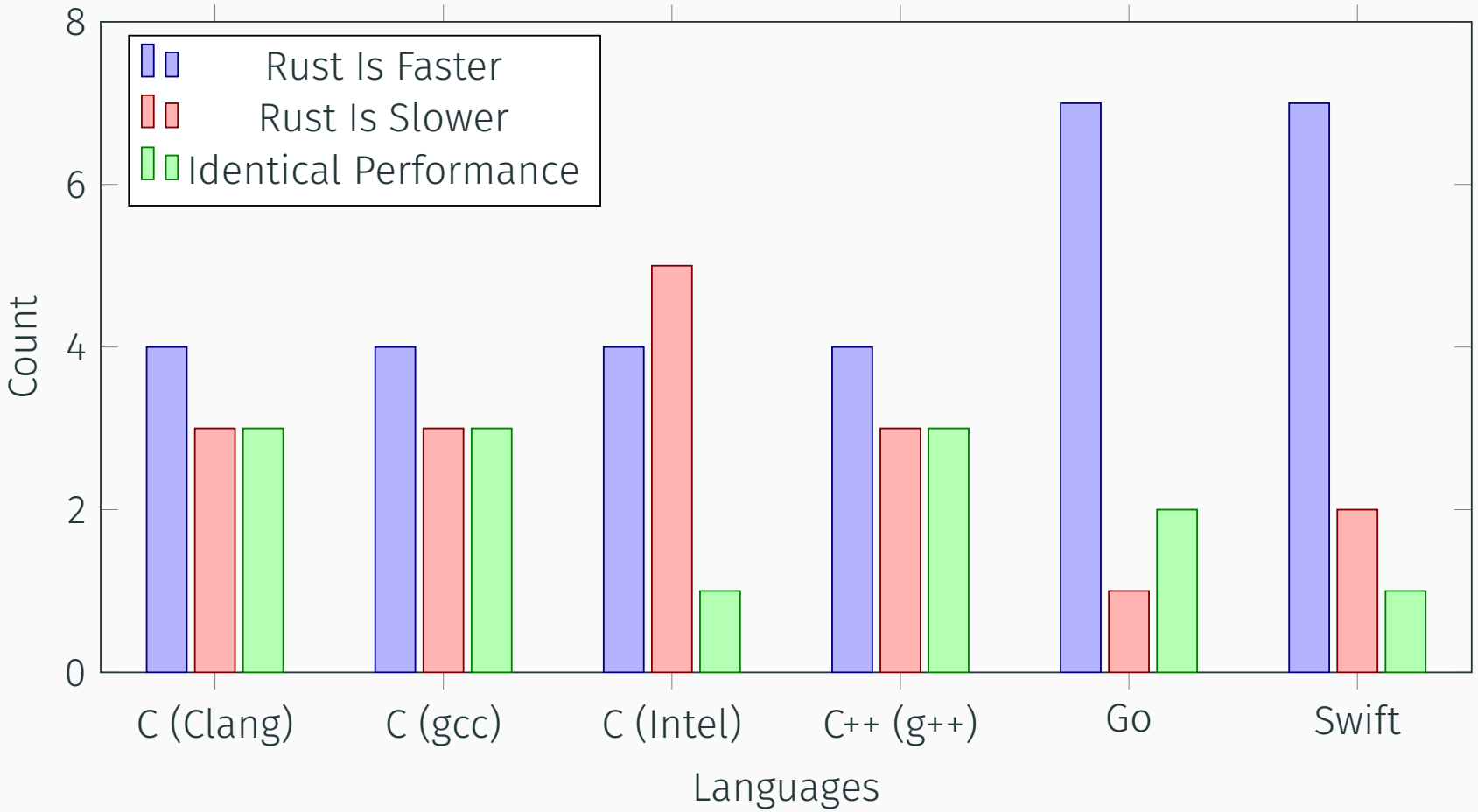

Figure 1: Comparison of Rust Performance with Other Languages

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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