TECHNISCHE UNIVERSITÄT MÜNCHEN

FAKULTÄT FÜR INFORMATIK

Garbage Collection & Reference Counting

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Overview

Methods of Memory Management

1. Shortcomings of Manual Memory Management
2. Garbage Collection
3. Rust’s approach

Memory Management in Rust

1. Stack Allocation
2. Heap Allocation with Box<T>
3. Reference counting in Rust
4. The ’unsafe’ keyword
5. The ’unsafe’ keyword

Common shortcomings of manual memory management

Garbage Collection

Example - Mark & Sweep

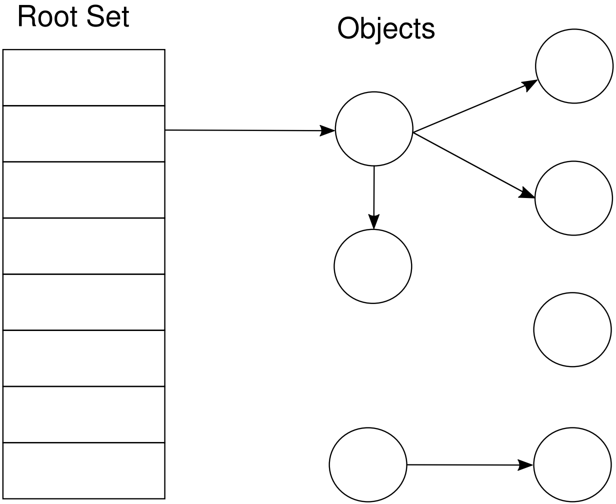


Figure: A graph-represenation of alive objects.

Example - Mark & Sweep

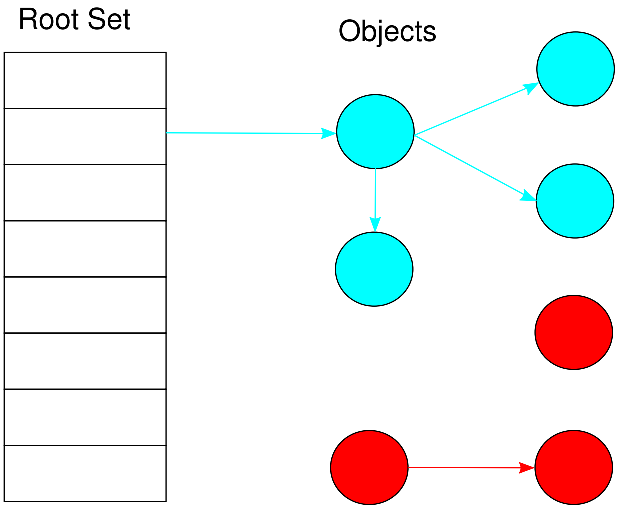


Figure: The 'Mark' stage of the algorithm.

Example - Mark & Sweep

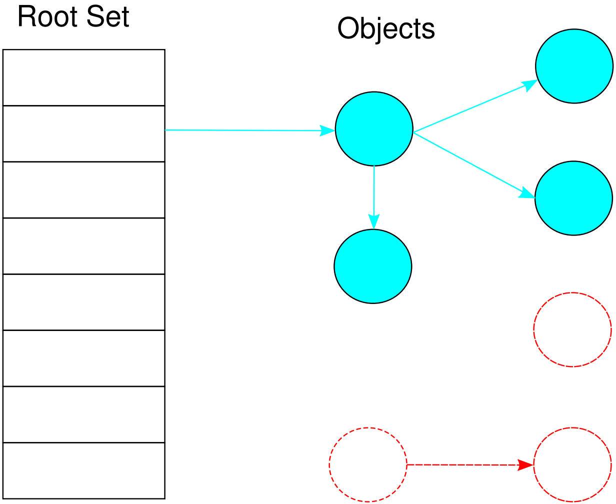


Figure: The 'Sweep' stage of the algorithm.

Memory management in Rust

Stack Allocation

Address	Name	Value
0	x	42

```rust
fn main() {
    let x = 42;
    other();
}

fn other() {
        let y = 27;
        let z = 99;
}
```

Stack Allocation

After line 8:

Address	Name	Value
2	z	99
1	y	27
0	x	42

```
1 fn main() {
2         let x = 42;
3         other();
4 }
5
6 fn other() {
7         let y = 27;
8         let z = 99;
9 }
```

Stack Allocation

After line 3:

Address	Name	Value
0	x	42

```
1  fn main() {
2          let x = 42;
3          other();
4  }
5
6  fn other() {
7          let y = 27;
8          let z = 99;
9  }
```

Advantages & Limitations

Heap Allocation

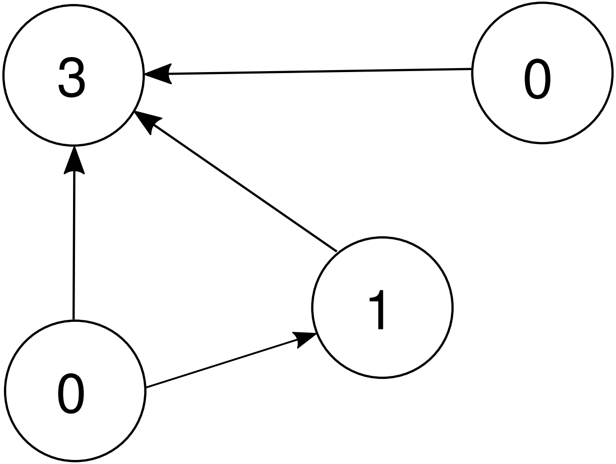
Workings of the Heap

Box<T> in Rust

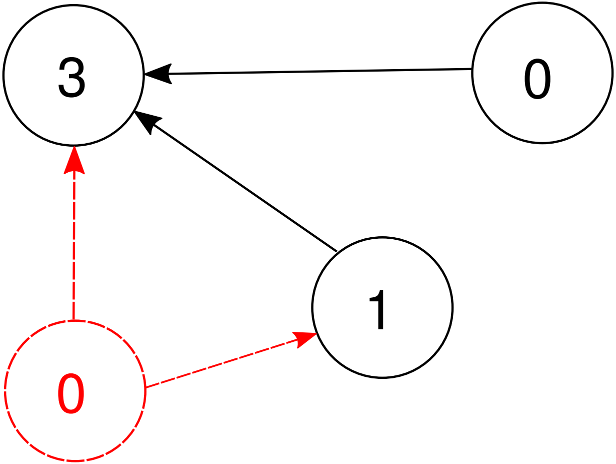
Use cases

Comparison: Heap vs. Stack

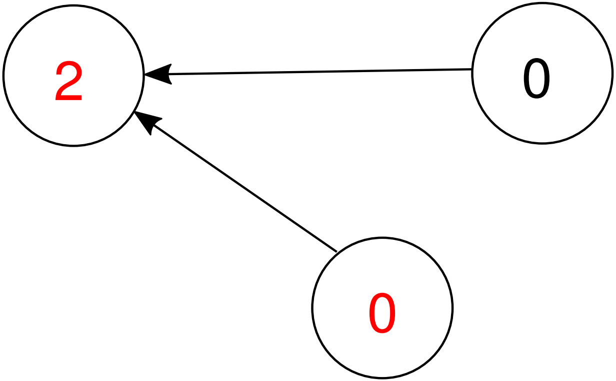
Reference Counting - Example



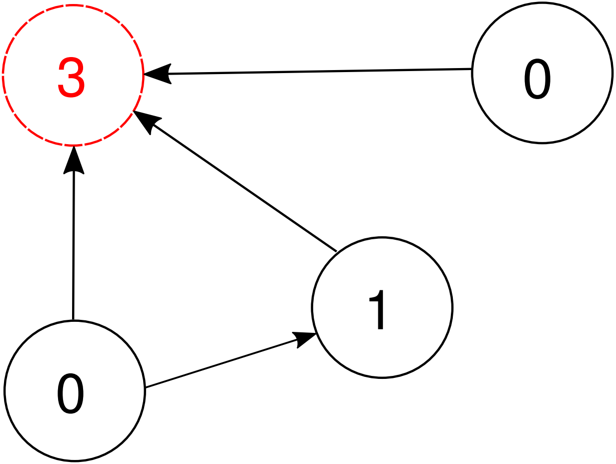
Reference Counting - Example



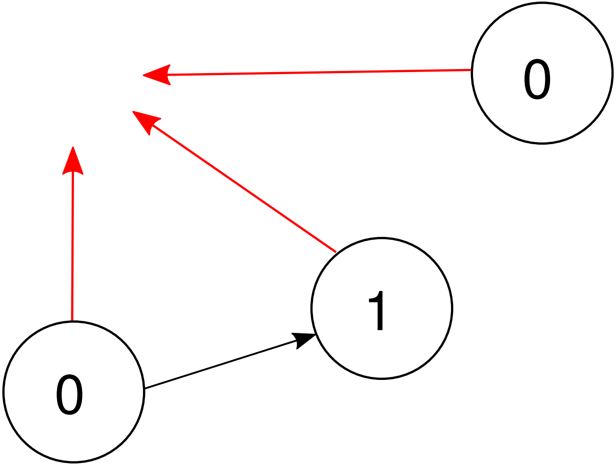
Reference Counting - Example



Reference Counting - Bad example



Reference Counting - Bad example



Limitations

⚠ Reference cycles can never be reclaimed!

Rc<T> (and Weak<T>) in Rust

Example

Limitations of Rc<T>

Multi-threaded Reference Counting with Arc<T>

Example

The ’unsafe’ keyword

Use cases