Rust Fundamentals

Basics of Rust
Part VI

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RustCourse
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Follow along!

- Rust Playground
- Exercises

▶ Show hints

Standard Library

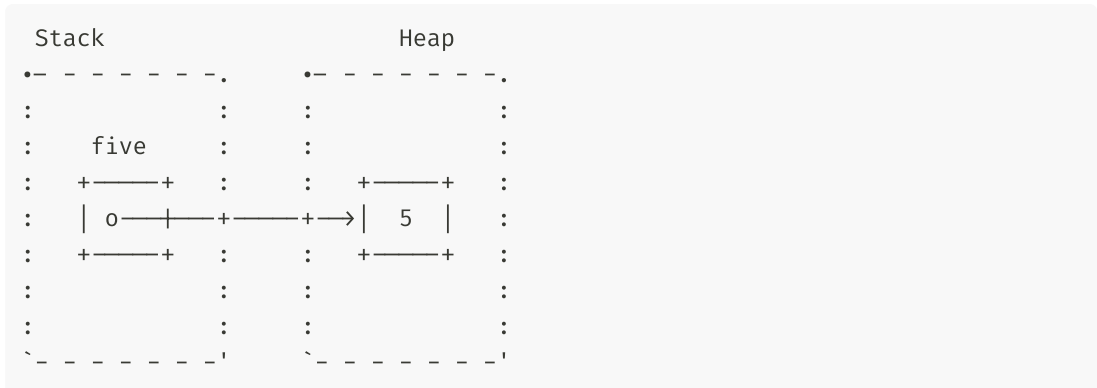
The common vocabulary types include:

- Box<T>: for allocating values on the heap.
- Rc<T>: a reference counting type that enables multiple ownership.

Box

- `Boxes` allow you to store data on the heap rather than the stack.

```
fn main() {
    let five = Box::new(5);
    println!("five: {}", five);
}
```



When to use `Box`?

- When the size of a type is unknown at compile time, but it's needed in a context that requires a fixed size.
- When transferring ownership of a large data chunk without copying it.
- When you want to own a value based on a specific trait, not a particular type.

```
fn main() {
    let five = Box::new(5);
    println!("five: {}", *five);
}
```

```
fn main() {
    let five = Box::new(5);
    println!("five: {}", five);
}
```

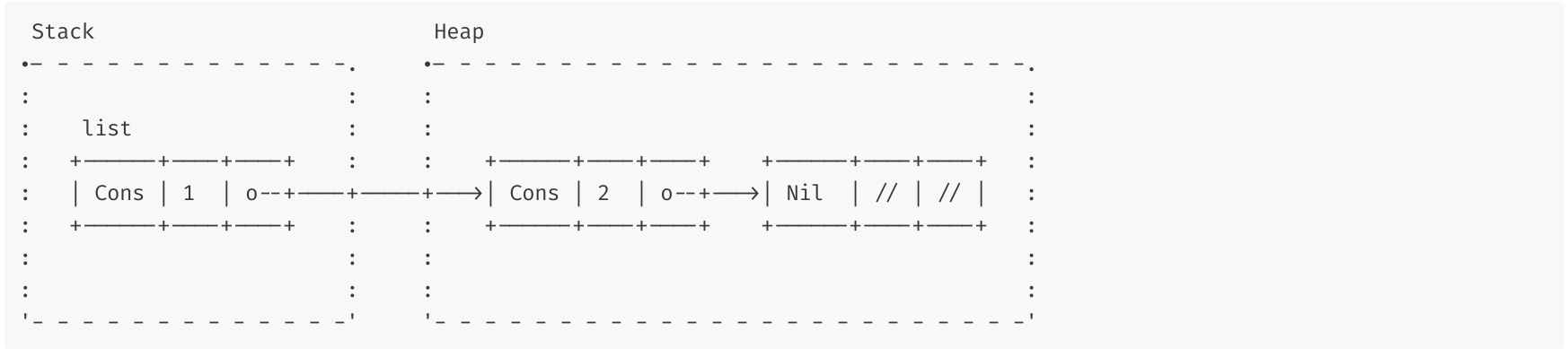
Box with Recursive Data Structures

Recursive data types or data types with dynamic sizes need to use a `Box`:

```
#[derive(Debug)]
enum List<T> {
    Cons(T, Box<List<T>>),
    Nil,
}

fn main() {
    let list: List<i32> = List::Cons(1, Box::new(List::Cons(2, Box::new(List::Nil))));
    println!("{list:?}");
}
```

- Recursive types pose an issue because, at compile time, Rust needs to know how much space a type takes up.
- The cons list isn't a commonly used data structure in Rust. Most of the time, `Vec\<T\>` is a better choice to us.


Stack
Heap
list
Cons | 1 | o
Cons | 2 | o
Nil | // | // |

The compiler is smart enough

Even if you missed the `Box`, the compiler is here for you!

```
error[E0072]: recursive type `List` has infinite size
 --> src/main.rs:2:1
  |
2 | enum List<T> {
  | ^^^^^^^^^^^^
3 |     Cons(T, List<T>),
  |             ------- recursive without indirection
  |
help: insert some indirection (e.g., a `Box`, `Rc`, or `&`) to break the cycle
  |
3 |     Cons(T, Box<List<T>>),
  |             ++++       +
```

- "Indirection" means that instead of storing a value directly, we should change the data structure to store the value indirectly by storing a pointer to the value instead.

Rc (Reference Counted)

```rust
use std::rc::Rc;

fn main() {
    let a = Rc::new(10);
    let b = Rc::clone(&a);

    println!("a: {a}");
    println!("b: {b}");
}
```

Exersices

- `box1.rs`
- `rc1.rs`

`box1.rs`

```
#[derive(PartialEq, Debug)]
pub enum List {
-   Cons(i32, List),
+   Cons(i32, Box<List>),
    Nil,
}

pub fn create_empty_list() -> List {
+    List::Nil
}

pub fn create_non_empty_list() -> List {
+    List::Cons(10, Box::new(List::Nil))
}
```

`rc1.rs`

`Rc::clone()` https://doc.rust-lang.org/std/rc/struct.Rc.html#method.clone

> This creates another pointer to the same allocation, increasing the strong reference count.

```
+    let saturn = Planet::Saturn(Rc::clone(&sun));
     println!("reference count = {}", Rc::strong_count(&sun)); // 7 references
     saturn.details();

+    let uranus = Planet::Uranus(Rc::clone(&sun));
     println!("reference count = {}", Rc::strong_count(&sun)); // 8 references
     uranus.details();

+    let neptune = Planet::Neptune(Rc::clone(&sun));

+    drop(earth);
     println!("reference count = {}", Rc::strong_count(&sun)); // 3 references

+    drop(venus);
     println!("reference count = {}", Rc::strong_count(&sun)); // 2 references

+    drop(mercury);
     println!("reference count = {}", Rc::strong_count(&sun)); // 1 reference
```

Generics

Generic Data Types

You can use generics to abstract over the concrete field type:

```
#[derive(Debug)]
struct Point<T> {
    x: T,
    y: T,
}

fn main() {
    let integer = Point { x: 5, y: 10 };
    let float = Point { x: 1.0, y: 4.0 };
    println!("{integer:?} and {float:?}");
}
```

```
struct Point<T> {
    x: T,
    y: T,
}

fn main() {
    let p = Point { x: 5, y: 10.0 };
}
```

Gives a compiler error:

```
error[E0308]: mismatched types
 --> src/main.rs:8:30
  |
8 |     let p = Point { x: 5, y: 10.0 };
  |                              ^^^^ expected integer, found floating-point number

For more information about this error, try `rustc --explain E0308`.
error: could not compile `playground` (bin "playground") due to previous error
```

Why? 🤔

Generic Methods

You can declare a generic type on your `impl` block:

```
#[derive(Debug)]
struct Point<T>(T, T);

impl<T> Point<T> {
    fn x(&self) -> &T {
        &self.0  // + 10
    }
}

fn main() {
    let p = Point(5, 10);
    println!("p.x = {}", p.x());
}
```

Monomorphization

Generic code is turned into non-generic code based on the call sites:

```
fn main() {
    let integer = Some(5);
    let float = Some(5.0);
}
```

Behaves as if you wrote

```
enum Option_i32 {
    Some(i32),
    None,
}

enum Option_f64 {
    Some(f64),
    None,
}

fn main() {
    let integer = Option_i32::Some(5);
    let float = Option_f64::Some(5.0);
}
```

Exercises

`generics1.rs`

```
fn main() {
-   let mut shopping_list: Vec<?> = Vec::new();
+   let mut shopping_list: Vec<&str> = Vec::new();
    shopping_list.push("milk");
}
```

`generics2.rs`

```
- struct Wrapper {
+ struct Wrapper<T> {
-     value: u32,
+     value: T,
}

- impl Wrapper {
+ impl<T> Wrapper<T> {
-     pub fn new(value: u32) -> Self {
+     pub fn new(value: T) -> Self {
        Wrapper { value }
    }
}
```

Credits 🌟

- Mo's (mo8it) Comprehensive Rust 🦀
- rustlings 🦀