

Consuming Rust bite by byte

Bite 1 - Data

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Why Rust?

- Memory and Data Race safety
 - Enforced data ownership rules insure Memory and Data Race safety.
- Error Handling
 - Any function that can fail returns a result indicating success or failure. Code has to handle errors in well defined ways.
- Performance
 - Rust compiles to native code and does not need garbage collection, so it is as fast as C and C++.
- Simple Value Behavior
 - Rust supports value behavior without the need to define copy and move constructors and assignment operators.
- Extraordinarily effective tool chain

What is this?

- This is the first in a series of bites - brief presentations - about the Rust programming language:
 - Each presentation will be brief – a few slides
 - Each will focus on one part of the Rust language
 - The series will build in bite sized chunks: easy to grasp, quick to consume.

Bite #1 – Rust Data

- Our goal is to understand the terms:
 - Bind – associate an identifier with a value
 - Copy – bind to a copy of a Copy type
 - Move – transfer ownership of a value
 - Clone – make a clone of a !Copy type

Bite #1 – Binding to a value

- Bind – associate an identifier with a memory location
 - Every identifier has a type:
 - `let k : i32 = 42;`
 - `let` signifies a binding is being created
 - `i32` is the type of a 32 bit integer
 - `42` is a value placed in the memory location associated with `k`
 - A type is a set of legal values with associated operations.
 - Type inference:
 - `let k = 42;`
 - This binding is legal and has the same meaning as the previous binding.
 - In lieu of other information, Rust will assign the type `i32` to any unadorned integral value that can be correctly written to a 32 bit location.

Bite #1 – Binding to an identifier

- Binding to an identifier has several forms:
 - `let j:i32 = k; // makes copy because k is blittable`
 - `let l = &k; // l makes reference to k, called a borrow`
 - `let s:String = "a string".into_string();`
 - `let t = s; // moves s into t, e.g., transfers ownership`
`// because s is not blittable`
- Blittable
 - A blittable type occupies a single contiguous block of memory, and so can be correctly copied to a new location with a single `memcpy`.
 - Non-blittable types occupy more than one memory location, usually one contiguous block on the stack and one or more blocks on the heap.
 - Non-blittable types cannot be successfully copied with a single `memcpy` operation.

Bite #1 - Ownership

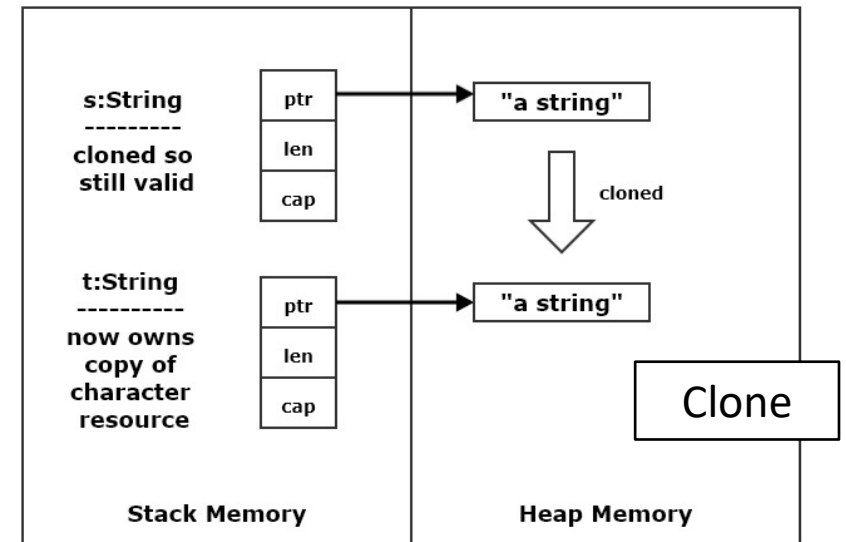
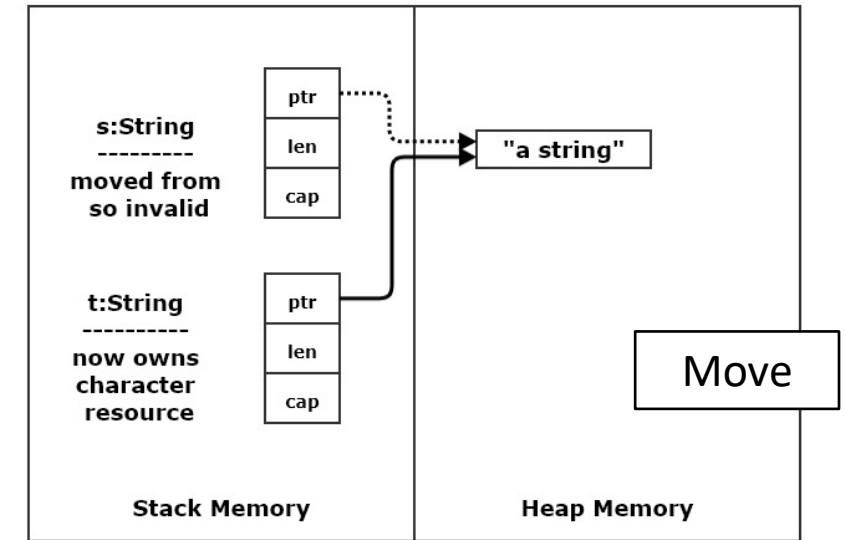
- Ownership in Rust is an interesting concept.
 - In Rust, data has one, and only one owner.
 - Ownership can be borrowed or transferred.
 - There are rules about ownership that we discuss in Bite #3.
 - Following Rust's ownership rules makes Rust code memory-safe.
 - Enforced by rustc, the Rust compiler
 - The rules also make Rust code free from data races
 - Rust will not compile code that is shared between threads unless it is guarded by a lock.
 - That, combined with single-ownership, ensures ordered access to shared data, one thread at a time.

Bite #1 – Copy and Borrow

- A copy operation can occur only for values that satisfy the Copy trait.
 - A trait is, like an interface, a specification of a contract. Copy contract requires Rust code, when binding, to copy data with that trait.
 - To satisfy Copy, the data must be blittable.
 - Copies happen implicitly when an identifier is bound to a Copy type.
 - `let i = 3; let j = i; // copy`
- Borrows - binding references to other identifiers
 - A reference is a safe pointer to the bound memory location.
 - `let r = &i;`

Bite #1 – Move and Clone

- A move transfers a Move type's heap resources to another instance of that type
 - The string, *s*, shown in the top diagram is moved to *t* with the statement:
 - `let t = s;`
 - Move transfers ownership of resources.
- A clone copies a Move type's heap resources to a new instance of that type.
 - The string *s*, shown in the bottom diagram is cloned with the statement:
 - `let t = s.clone();`
 - Clone operation copies resources to target.



Exercises

1. Create an instance of a blittable type and show when it is copied.
 - Can you prove that it was copied?
2. Create an instance of a non-blittable type and show when it is moved.
 - Can you prove that it was moved?
3. Repeat the second exercise but clone the non-blittable type before moving it. Show that the clone is valid while the move source is not valid.

Hint:

- Integral types, chars, and floating-point types are blittable
- Strings, Vecs, VecDeque, and Maps are non-blittable.

References

Link	Description
ConsumingRustBite2 - UDB	Undefined behavior – example from C++ code
Rust Story - Data	Expanded discussion in Rust Story

That's all until Bite #2

Bite #2 illustrates undefined behavior with C++ code, showing us why we need Rust.