Fluence Compute Engine (FCE), interior mutability, and TryInto

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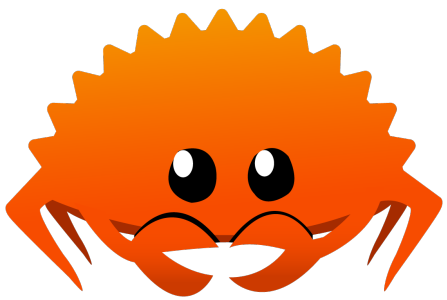
RustGraz community



Fluence Compute Engine

FCE

What is FCE?

> *Fluence Compute Engine (FCE) is a general purpose Wasm runtime that could be used in different scenarios, especially in programs based on the ECS pattern or plugin architecture. It runs multi-module WebAssembly applications with interface-types and shared-nothing linking scheme.*

Presentation by michaelvoronov:

> *Mike Voronov has more than 10 years of experience in C++ and 2+ years experience in Rust and WebAssembly*

Interior mutability

Reference semantics

Revision: shared versus mutable references.

```
fn overwrite(base: &u32, new_value: &u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile?

Reference semantics

Revision: shared versus mutable references.

```
fn overwrite(base: &u32, new_value: &u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile? No, *lifetime mismatch*.

Reference semantics

```
fn overwrite<'a>(base: &'a u32,
                 new_value: &'a u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile?

Reference semantics

```
fn overwrite<'a>(base: &'a u32,
                 new_value: &'a u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile? No, *cannot assign to immutable argument 'base'* .

Reference semantics

```
fn overwrite<'a>(mut base: &'a u32,
                 new_value: &'a u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile?

Reference semantics

```
fn overwrite<'a>(mut base: &'a u32,
                 new_value: &'a u32) {
  base = new_value;
}
fn main() {
  let value = 3;
  overwrite(&value, &42);
  println!("{}", value);
}
```

Does it compile? Yes, but prints 3, not 42.

Reference semantics

Modifying the reference …

```
fn overwrite<'a>(mut base: &'a u32,
                 new_value: &'a u32);
```

versus

```
fn overwrite<'a>(base: &'a mut u32,
                 new_value: &'a u32);
```

… modifying the value behind a reference.

Reference semantics

```
fn overwrite<'a>(base: &'a mut u32,
                 new_value: &'a u32) {
  *base = *new_value;
}
fn main() {
  let mut value = 3;
  overwrite(&mut value, &mut 42);
  println!("{}", value); // prints 42
}
```

Excursion: constant variables

Small excursion: Benedikt also pointed out the following snippet:

```
fn overwrite<'a>(base: &'a mut u32,
                 new_value: &'a u32) {
  *base = *new_value;
}
fn main() {
  let mut value = 3;
  overwrite(&mut 42, &mut 42);
  println!("{}", value); // prints 3
}
```

Apparently, rust creates *two* local variables with value *42*. This is interesting since constants of same value need not be allocated twice usually.

Mutability semantics

1. A variable is mutable; or not.
2. A reference is mutable; or not.
3. If a struct instance bound to a variable is mutable; its members are mutable too (*inherited mutability*).
4. Mutability checks happen at *compile time*.

```
struct User {
  id: u32,
  posts_count: u32,
}
let mut meisterluk = User {
  id: 1,
  posts_count: 42
};
```

What about a data structure that modifying elements in the background without knowledge of the user?

Interior mutability types in rust

Multithreaded? Use atomic datatypes or locks (Mutex, RwLock, …)!
Otherwise, …

`Cell<T>` Provides interior mutability for some value.

`RefCell<T>` Provides interior mutability for some value and returns references in its API.

`UnsafeCell<T>` Underlying primitive for the types above

… implemented with *runtime* checks!

Cell

`Cell<T>`: This type wraps an existing value and provides interior mutability.

```
use std::cell::Cell;
struct User {
  id: u32,
  count_posts: Cell<u32>,
}

fn main() {
  let meisterluk = User {
    id: 1,
    count_posts: Cell::new(42),
  };
  // meisterluk.id = 4;  // error: meisterluk is not mutable
  meisterluk.count_posts.replace(55);
  println!("User=({}, {})",
    meisterluk.id,
    meisterluk.count_posts.get()
  );
}
```

Cell API

`Cell<T>`: This type wraps an existing value and provides interior mutability.

1. `pub const fn new(value: T) -> Cell<T>`
2. `pub fn set(&self, val: T)`
3. `pub fn swap(&self, other: &Cell<T>)`
4. `pub fn replace(&self, val: T) -> T`
5. `pub fn into_inner(self) -> T`
6. `pub const fn new(value: T) -> Cell<T>`

RefCell

`RefCell<T>`: This type wraps an existing value and provides references for interior mutability.

```
use std::cell::RefCell;

struct User {
  id: u32,
  count_posts: RefCell<u32>,
}

fn main() {
  let meisterluk = User {
    id: 1,
    count_posts: RefCell::new(42),
  };
  meisterluk.count_posts.replace(55);
  println!("User=({}, {})",
           meisterluk.id,
           meisterluk.count_posts.borrow());
}
```

RefCell API

1. `pub const fn new(value: T) -> RefCell<T>`
2. `pub fn borrow(&self) -> Ref<'_, T>`
3. `pub fn try_borrow(&self) -> Result<Ref<'_, T>, BorrowError>`
4. `pub fn borrow_mut(&self) -> RefMut<'_, T>`
5. `pub fn try_borrow_mut(&self) -> Result<RefMut<'_, T>, BorrowMutError>`
6. `pub fn as_ptr(&self) -> *mut T`
7. `pub fn get_mut(&mut self) -> &mut T`
8. `pub unsafe fn try_borrow_unguarded(&self) -> Result<&T, BorrowError>`

RefCell

```
use std::cell::RefCell;

struct User {
  id: u32,
  count_posts: RefCell<u32>,
}

fn main() {
  let meisterluk = User {
    id: 1,
    count_posts: RefCell::new(42),
  };
  let a = meisterluk.count_posts.borrow_mut();
  let _ = meisterluk.count_posts.borrow_mut();
}
```

Runtime error!

```
thread 'main' panicked at 'already borrowed: BorrowMutError',
      src/main.rs:14:36
note: run with `RUST_BACKTRACE=1` environment variable
      to display a backtrace
```

TryInto / Into / TryFrom / From

Motivation

1. Sometimes it is convenient to convert one type into another (*coercion*, *casting*)
2. Usually done explicitly in rust with `as` keyword
3. But when calling a function, we often know the source and target target. How can we convert it?

4 traits

```
pub trait Into<T>: Sized {
  fn into(self) -> T;
}
pub trait TryInto<T>: Sized {
  type Error;
  fn try_into(self)
    -> Result<T, Self::Error>;
}
pub trait From<T>: Sized {
  fn from(_: T) -> Self;
}
pub trait TryFrom<T>: Sized {
  type Error;
  fn try_from(value: T)
    -> Result<Self, Self::Error>;
}
```

4 traits

1. Try traits permit conversion to fail.
2. All traits are reflexive (T can be converted *into* T).
3. Prefer to implement `TryFrom` instead of `TryInto`
4. Implementing `From` automatically provides one with an implementation of `Into`.

Example implementation

Example via Rust by Example:

```
use std::convert::{TryFrom, TryInto};

#[derive(Debug, PartialEq)]
struct EvenNumber(i32);

impl TryFrom<i32> for EvenNumber {
  type Error = ();
  fn try_from(value: i32)
    -> Result<Self, Self::Error>
  {
    if value % 2 == 0 {
        Ok(EvenNumber(value))
    } else {
        Err(())
} } }
```

Example implementation

```
fn main() {
  // TryFrom
  assert_eq!(EvenNumber::try_from(8),
             Ok(EvenNumber(8)));
  assert_eq!(EvenNumber::try_from(5),
             Err(()));

  // TryInto
  let result: Result<EvenNumber, ()> = 8i32.try_into();
  assert_eq!(result, Ok(EvenNumber(8)));
  let result: Result<EvenNumber, ()> = 5i32.try_into();
  assert_eq!(result, Err(()));
}
```

Strings to vectors

Strings can be converted into a vector of bytes.

```
fn main() {
    let a: Vec<u8> = String::from("hello").into();
    println!("{}", a[0]);
}
```

Into as trait bound

Trait bounds can specify that any type convertible into another will be accepted.

```
fn is_hello<T: Into<Vec<u8>>>(s: T) {
  let bytes = b"hello".to_vec();
  assert_eq!(bytes, s.into());
}

let s = "hello".to_string();
is_hello(s);
```

Epilogue

Quiz

Who maintains the WASM standard?

What is mutable about a mutable reference?

How can you implement casting for your own type?

When do you implement Into instead of TryInto?

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WebAssembly became a World Wide Web Consortium recommendation in Dec 2019

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Implement Into/TryInto or From/TryFrom

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What is mutable about a mutable reference?

The value the reference is pointing to

How can you implement casting for your own type?

Implement Into/TryInto or From/TryFrom

When do you implement Into instead of TryInto?

If the conversion cannot fail under any circumstances.

Next time

Next meetup	Wed, 2021/01/27
Topic	Cross-compilation: compiling for the raspberry PI

Thank you!