CMSC 330: Organization of Programming Languages

Traits

Overview

- Traits abstract behavior that types can have in common
  - Traits are a bit like Java interfaces
  - But we can implement traits over any type, anywhere in the code, not only at the point we define the type

- Trait bounds can be used to specify when a generic type must implement a trait
  - Trait bounds are like Java's bounded type parameters

Defining a Trait

- Here is a trait with a single function

```
pub trait Summarizable {
  fn summary(&self) -> String;
}
```

  - Specify **`&self`** for "instance" methods
    - – Can also specify "associated" methods
      - » Like **`static`** methods in Java

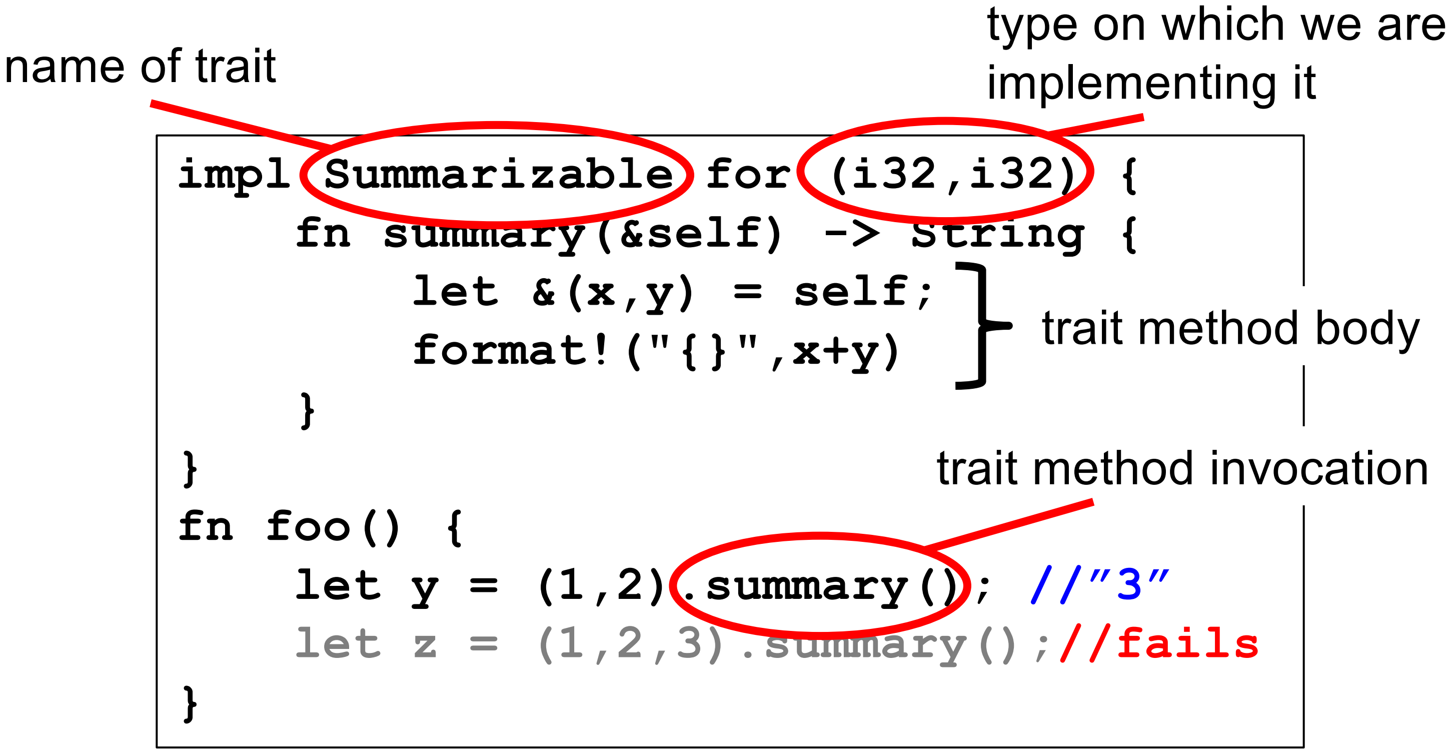
- Equivalent in Java:

```
public interface Summarizable {
  public String summary();
}
```

Note: The keyword **`pub`** makes any module, function, or data structure accessible from inside of external modules. The **`pub`** keyword may also be used in a **`use`** declaration to re-export an identifier from a namespace.

Note that we make the entire trait public, not individual elements of it.

Implementing a Trait on a Type



name of trait

type on which we are implementing it

```
impl Summarizable for (i32,i32) {
    fn summary(&self) -> String {
        let &(x,y) = self;
        format!("{}",x+y)
    }
}
fn foo() {
    let y = (1,2).summary(); //”3”
    let z = (1,2,3).summary();//fails
}
```

trait method body

trait method invocation

Default Implementations

- Here is a trait with a default implementation

```
pub trait Summarizable {
   fn summary(&self) -> String {
      String::from(“none”)
   }
}
```

default impl

Impl uses default

```
impl Summarizable for (i32,i32,i32) {}
fn foo() {
      let y = (1,2).summary(); //”3”
      let z = (1,2,3).summary();//”none”
}
```

Trait Bounds

- With generics, you can specify that a type variable must implement a trait

```
pub fn notify<T: Summarizable>(item: T) {
  println!("Breaking news! {}",
                item.summary());
}
```

  – This method works on any type **T** that implements the **Summarizable** trait
    - This is a kind of subtyping: **T** can have many methods but at the least it should implement those in the **Summarizable** trait

Trait Bounds: Like Java Bounded Parameters

- Equivalent in Java

```
<T extends Summarizable>
void notify(T item) {
  System.out.println("Breaking news! "+
                     item.summary());
}
```

  - This generic method works on any type **T** that implements the **Summarizable** interface (which we showed before)

```
public interface Summarizable {
  public String summary();
}
```

Generics, Multiple Bounds

- Trait implementations can be generic too

```
pub trait Queue<T> {
   fn enqueue(&mut self, ele: T) -> (); …
}
impl <T> Queue<T> for Vec<T> {
   fn enqueue(&mut self, ele:T) -> () {…} …
}
```

- Generic method implementations of structs and enums can include trait bounds
- Can specify multiple Trait Bounds using **+**

```
fn foo<T:Clone + Summarizable>(…) -> i32 {…}    or
fn foo<T>(…) -> i32 where T:Clone + Summarizable {…}
```

(Non)Standard Traits

- We have seen several standard traits already
  - `Clone` holds if the object has a `clone()` method
  - `Copy` holds if assignment duplicates the object
    - I.e., no ownership transfer, as with primitive types
  - `Deref` holds if you can dereference it
    - I.e., it's a primitive reference, or has a **`deref()`** method
- There are other useful ones too
  - `Display` if it can be converted to a string
  - `PartialOrd` if it implements a comparison operator

Putting all Together

- Finds the largest element in an array slice
  - Generic in the type T of the contents of the array

```
fn largest<T: PartialOrd + Copy>(list: &[T]) -> T
{
    let mut largest = list[0];
    for &item in list.iter() {
        if item > largest {
            largest = item;
        }
    }
    largest
}
```

Requires Copy trait to not transfer ownership

Requires PartialOrd trait

Putting all Together

- Finds the largest element in an array slice
  - Generic in the type **T** of the contents of the array

```
fn largest<T: PartialOrd + Copy>(list: &[T]) -> T
{…}
fn main() {
    let number_list = vec![34, 50, 25, 100, 65];
    let result = largest(&number_list);
    println!("The largest number is {}", result);
    let char_list = vec!['y', 'm', 'a', 'q'];
    let result = largest(&char_list);
    println!("The largest char is {}", result);
}
```

prints

```
The largest number is 100
The largest char is y
```