4-3: Procedural and declarative macros (Theory)

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Macros

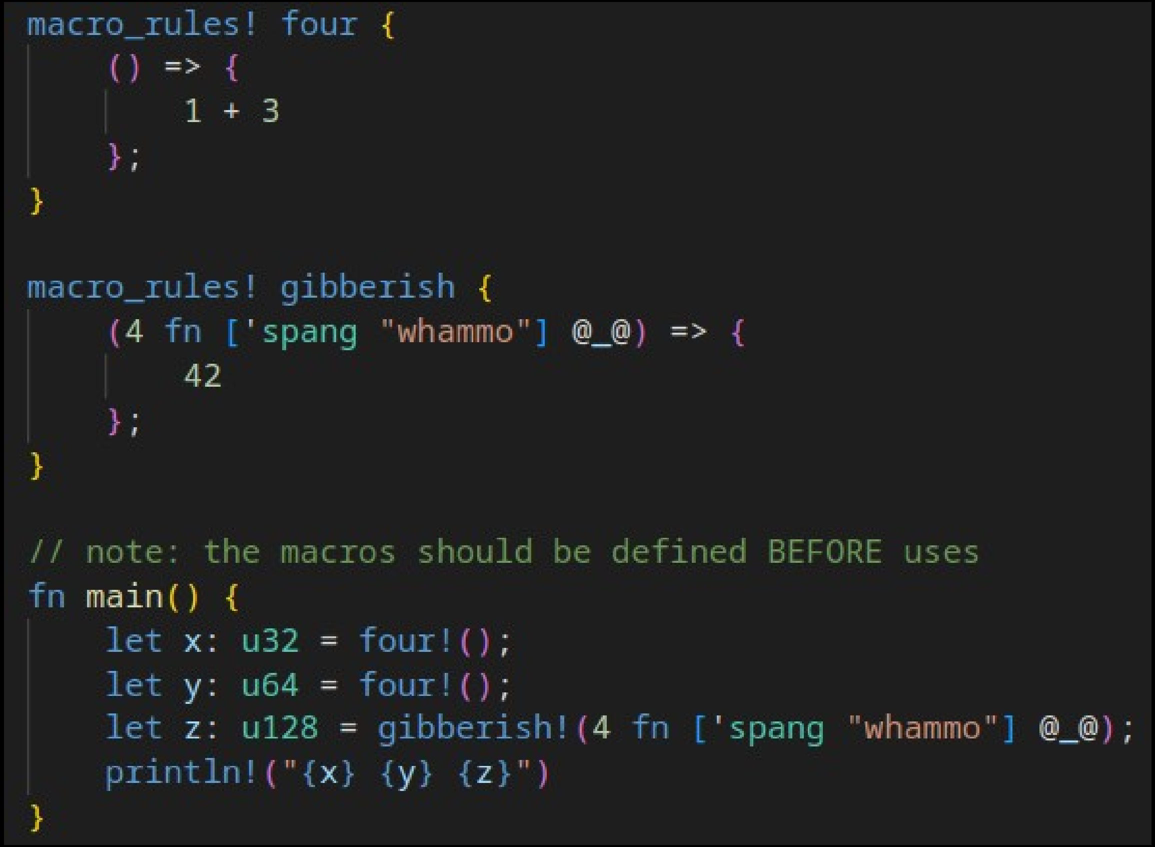
- Rust has 4 kinds of macros:
  - Declarative macros defined with macro_rules!
  - Procedural macros:
    - Custom #[derive] macros that specify code added with the derive attribute used on structs and enums
    - Attribute-like macros that define custom attributes usable on any item
    - Function-like macros that look like function calls but operate on the tokens specified as their argument
- Macro must be defined orbrought into scope before its called
- All procedural macros accept TokenStream and return TokenStream

Declarative macros

- Sometimes referred to as “macros by example,” “macro_rules! macros,” or just plain “macros”
- macro_rules! uses the following form:

```
macro_rules! $name {
    ($matcher0) => {$expansion0} ;
    ($matcher1) => {$expansion1} ;
    // …
    ($matcherN) => {$expansionN} ;
}
```

Primitive macros

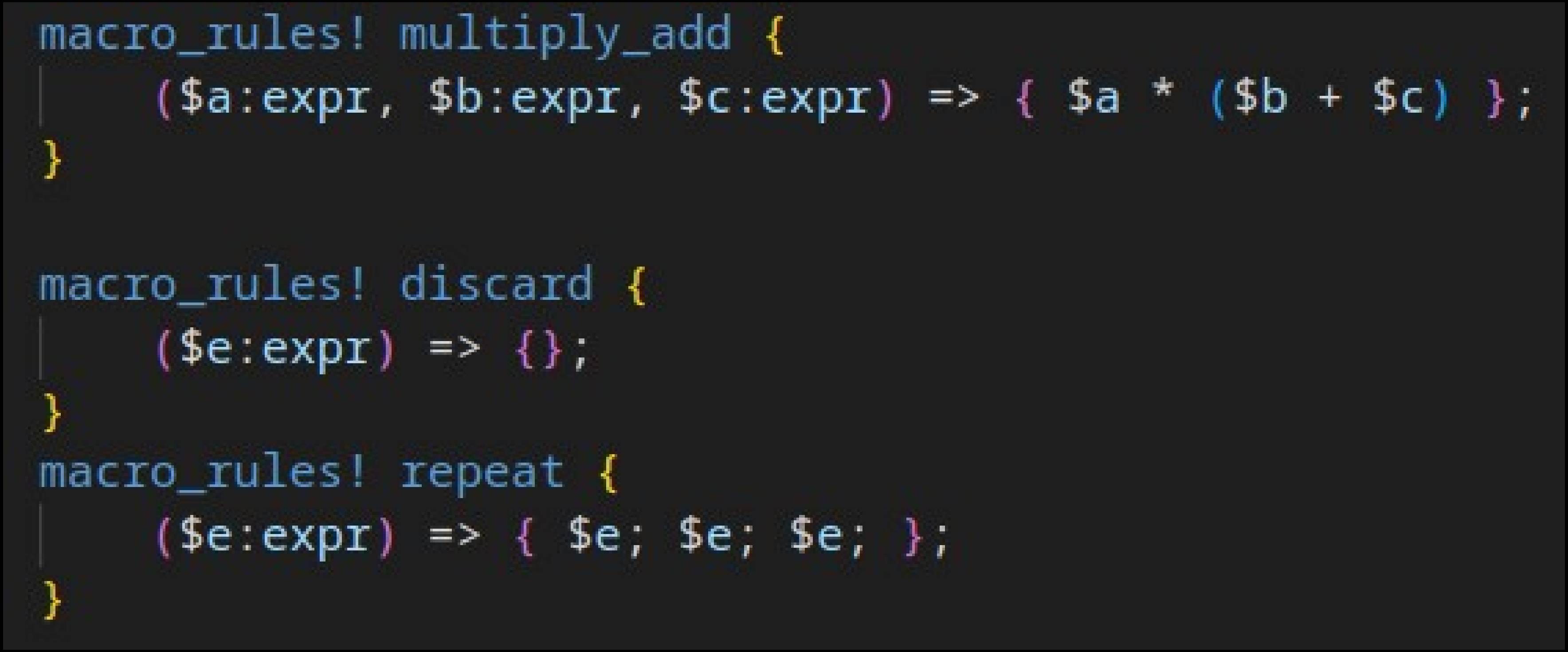


```rust
macro_rules! four {
    () => {
        1 + 3
    };
}

macro_rules! gibberish {
    (4 fn ['spang "whammo"] @_@) => {
        42
    };
}

// note: the macros should be defined BEFORE uses
fn main() {
    let x: u32 = four!();
    let y: u64 = four!();
    let z: u128 = gibberish!(4 fn ['spang "whammo"] @_@);
    println!("{x} {y} {z}")
}
```

Captures

- Matchers can also contain captures.
- Captures are written as a dollar ($) followed by an identifier, a colon (:), and finally the kind of capture:
  - block: a block (i.e. a block of statements and/or an expression, surrounded by braces)
  - expr: an expression
  - ident: an identifier (this includes keywords)
  - item: an item, like a function, struct, module, impl, etc.
  - lifetime: a lifetime (e.g. 'foo, 'static, etc.)
  - literal: a literal (e.g. "Hello World!", 3.14, etc.)
  - meta: a meta item; the things that go inside the #[...] and #![...] attributes
  - pat: a pattern
  - path: a path (e.g. foo, ::std::mem::replace, transmute::<_, int>, etc.)
  - stmt: a statement
  - tt: a single token tree
  - ty: a type
  - vis: a possible empty visibility qualifier (e.g. pub, pub(in crate), etc.)

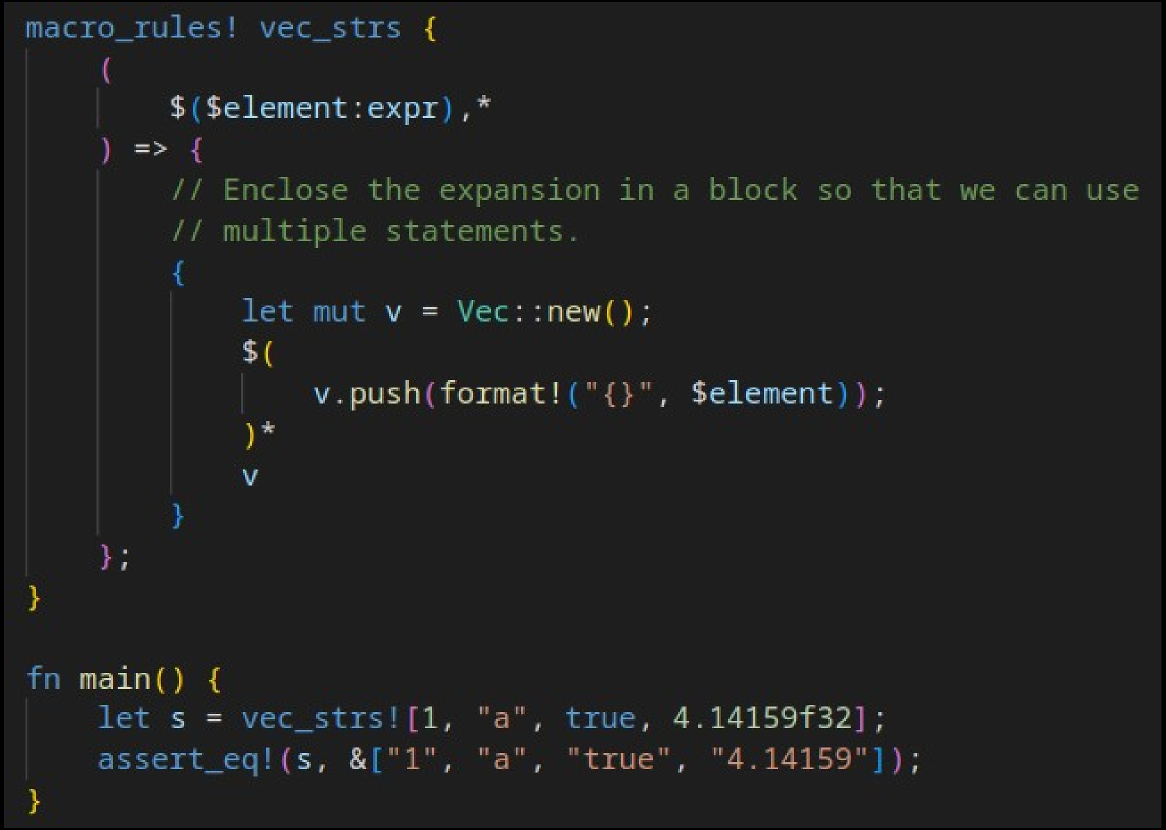
Simple capture


```
macro_rules! multiply_add {
    ($a:expr, $b:expr, $c:expr) => { $a * ($b + $c) };
}

macro_rules! discard {
    ($e:expr) => {};
}
macro_rules! repeat {
    ($e:expr) => { $e; $e; $e; };
}
```

Repetitions

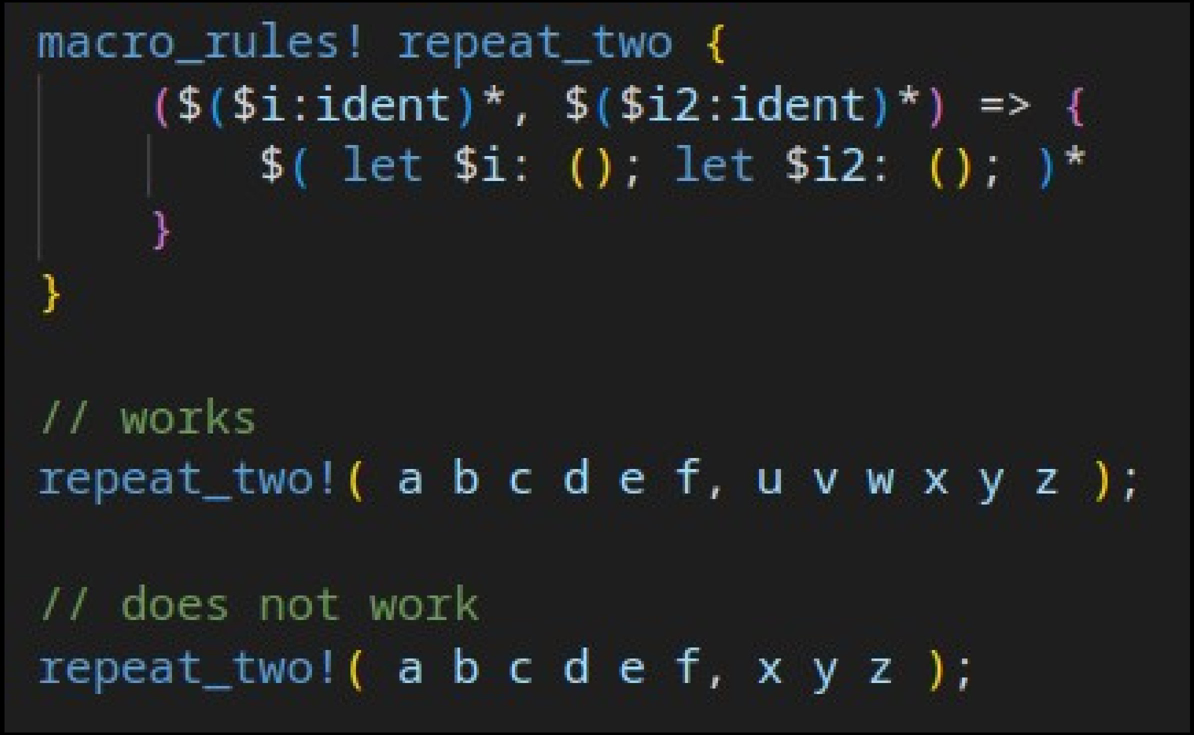
- Matchers can contain repetitions.
- Repetitions have the general form $ (...) sep rep:
  - $ is a literal dollar token.
  - (...) is the paren-grouped matcher being repeated.
  - sep is an optional separator token. Common examples are , and ;
  - rep is the required repeat operator. Currently, this can be:
    - ?: indicating at most one repetition
    - *: indicating zero or more repetitions
    - +: indicating one or more repetitions
- Since ? represents at most one occurrence, it cannot be used with a separator.

Simple repetition



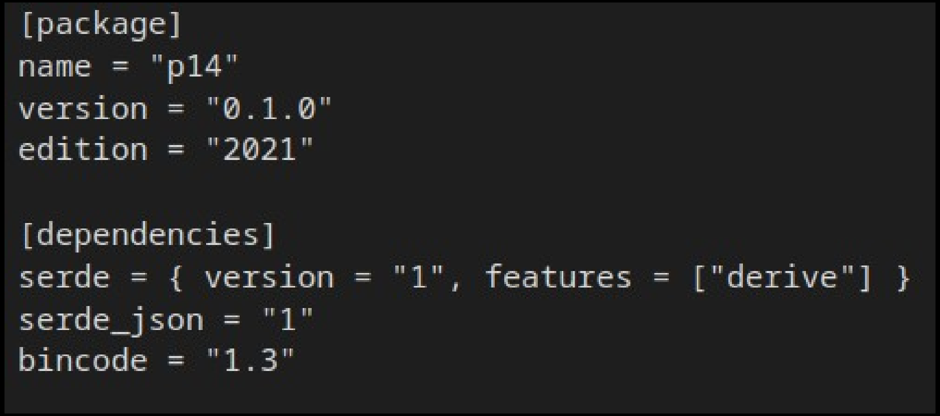
```rust
macro_rules! vec_strs {
    (
        $($element:expr),*
    ) => {
        // Enclose the expansion in a block so that we can use
        // multiple statements.
        {
            let mut v = Vec::new();
            $(
                v.push(format!("{}", $element));
            )*
            v
        }
    };
}

fn main() {
    let s = vec_strs![1, "a", true, 4.14159f32];
    assert_eq!(s, &["1", "a", "true", "4.14159"]);
}
```

Multiple repetitions

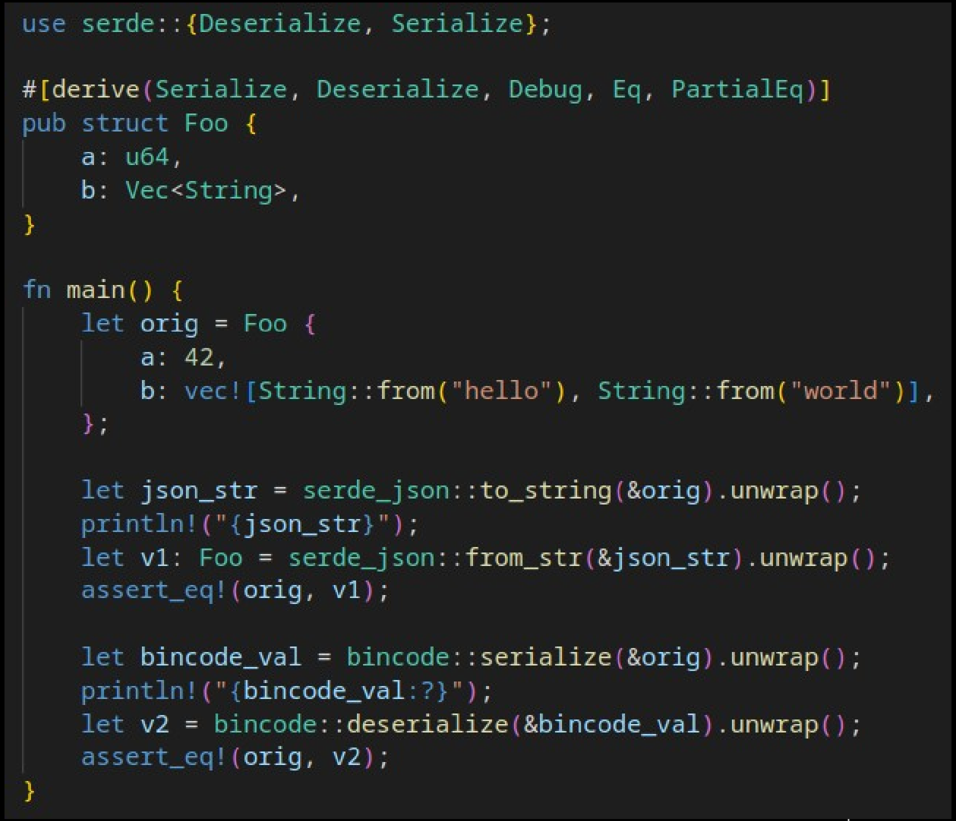


```
macro_rules! repeat_two {
    ($($i:ident)*, $($i2:ident)*) => {
        $( let $i: (); let $i2: (); )*
    }
}

// works
repeat_two!( a b c d e f, u v w x y z );

// does not work
repeat_two!( a b c d e f, x y z );
```

Custom derive and serde



```toml
[package]
name = "p14"
version = "0.1.0"
edition = "2021"

[dependencies]
serde = { version = "1", features = ["derive"] }
serde_json = "1"
bincode = "1.3"
```



```rust
use serde::{Deserialize, Serialize};

#[derive(Serialize, Deserialize, Debug, Eq, PartialEq)]
pub struct Foo {
    a: u64,
    b: Vec<String>,
}

fn main() {
    let orig = Foo {
        a: 42,
        b: vec![String::from("hello"), String::from("world")],
    };

    let json_str = serde_json::to_string(&orig).unwrap();
    println!("{json_str}");
    let v1: Foo = serde_json::from_str(&json_str).unwrap();
    assert_eq!(orig, v1);

    let bincode_val = bincode::serialize(&orig).unwrap();
    println!("{bincode_val:?}");
    let v2 = bincode::deserialize(&bincode_val).unwrap();
    assert_eq!(orig, v2);
}
```

Questions?