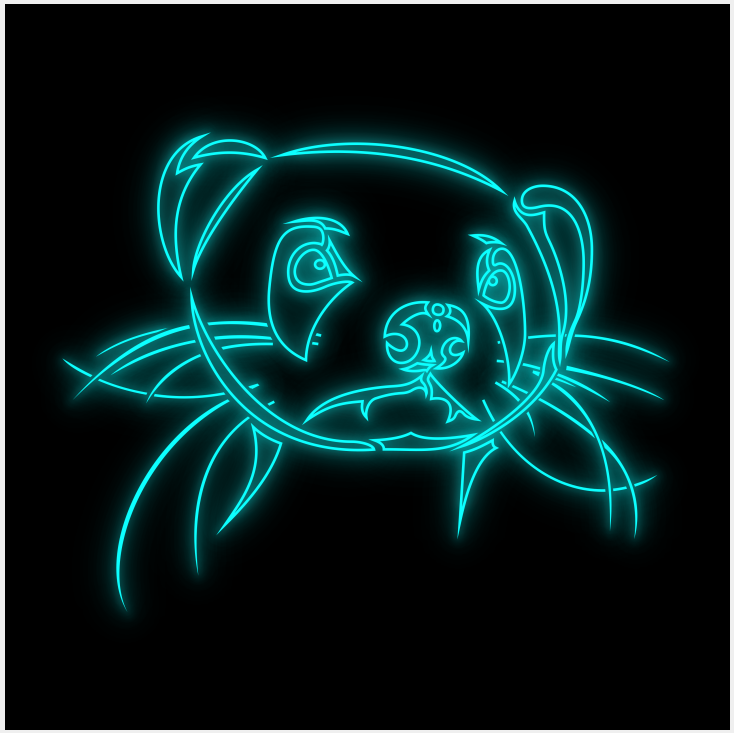
Anything you can do, I can do worse with `macro_rules!`

Aurorans Solis
any/any

AuroransSolis
AuroransSolis
aurorans_solis



Quick Refresher

Easing Into It

A few quick things:

Easing Into It

A few quick things:

- `@something` in a macro invocation isn't special syntax.

Easing Into It

A few quick things:

- `@something` in a macro invocation isn't special syntax.
- We use recursion a lot in macros because an individual rule itself cannot be recursive, ambiguous, or violate Rust's parsing ambiguity rules.

Hold on, that's a lot

1. A rule cannot be recursive?

Hold on, that's a lot

1. A rule cannot be recursive?
   - Rules only have regex-like repetition specifiers: `?`, `*`, and `+`. This doesn't give the tools for recursion.

Hold on, that's a lot

1. A rule cannot be recursive?
   - Rules only have regex-like repetition specifiers: `?`, `*`, and `+`. This doesn't give the tools for recursion.
2. A rule cannot be ambiguous?

Hold on, that's a lot

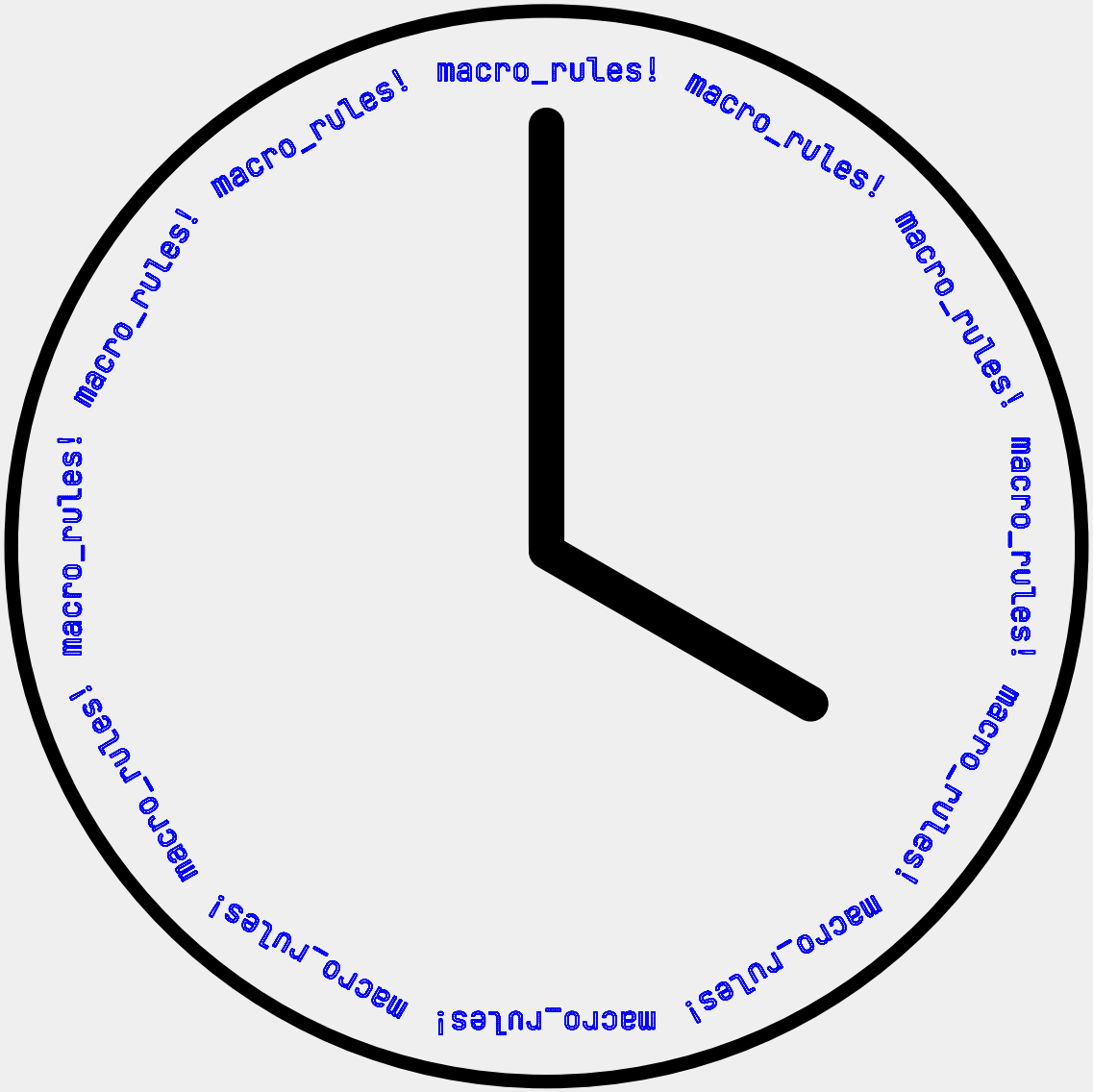
1. A rule cannot be recursive?
   - Rules only have regex-like repetition specifiers: `?`, `*`, and `+`. This doesn't give the tools for recursion.
2. A rule cannot be ambiguous?
   - A rule must only be able to be applied in one way to a particular input. For example, `($($foo:tt)? $bar:tt)` is ambiguous on the input `baz`.

Hold on, that's a lot

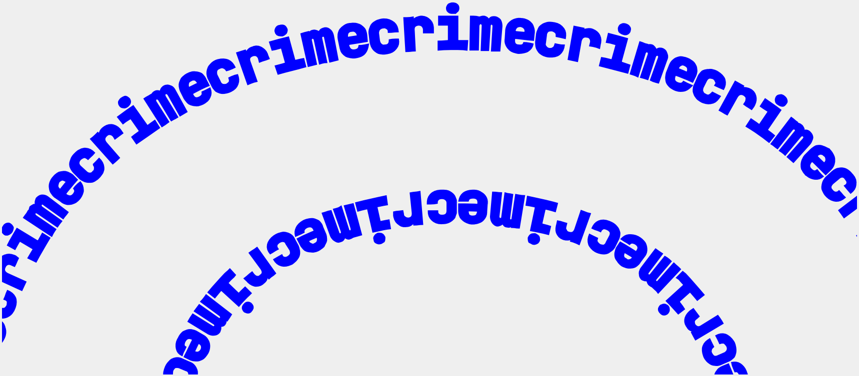
1. A rule cannot be recursive?
   - Rules only have regex-like repetition specifiers: `?`, `*`, and `+`. This doesn't give the tools for recursion.
2. A rule cannot be ambiguous?
   - A rule must only be able to be applied in one way to a particular input. For example, `($($foo:tt)? $bar:tt)` is ambiguous on the input `baz`.
3. A rule cannot violate Rust's parsing ambiguity rules?

Hold on, that's a lot

1. A rule cannot be recursive?
   - Rules only have regex-like repetition specifiers: `?`, `*`, and `+`. This doesn't give the tools for recursion.
2. A rule cannot be ambiguous?
   - A rule must only be able to be applied in one way to a particular input. For example, `($($foo:tt)? $bar:tt)` is ambiguous on the input `baz`.
3. A rule cannot violate Rust's parsing ambiguity rules?
   - You cannot have unpaired ( ), [ ], or { }.
   - You cannot have certain token types come before anything except certain allowed tokens (follow set ambiguity)


macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!
macro_rules!

macro_rules!


crimecrimecrimecrimecrimecrimec

It’s not snacktime anymore. It’s crimetime.
We’re going to define traits using XML and declarative macros.

The Horrors

Start of the evil arc

We’re going to take this trait:

```
pub trait Foo<const BAR: usize>: Baz {
    type Baq: Qux;
    const QUUX: Self::Baq;
    fn corge<Grault, Garply>(waldo: Grault) → Garply;
}
```

And turn it into this XML:

```xml
<trait>
    <name>Foo</name>
    <vis>pub</vis>
    <bounds>
        <const>
            <name>BAR</name>
            <type>usize</type>
        </const>
        <req>Baz</req>
    </bounds>
    <assoctype>
        <name>Baq</name>
        <bounds>
            <req>Qux</req>
        </bounds>
    </assoctype>
    <assocconst>
        <name>QUUX</name>
        <type>Self::Baq</type>
    </assocconst>
    <assocfn>
        <name>corge</name>
        <bounds>
            <type>
                <name>Grault</name>
            </type>
            <type>
                <name>Garply</name>
            </type>
        </bounds>
        <args>
            <arg>
                <name>waldo</name>
                <type>Grault</type>
            </arg>
        </args>
        <ret>Garply</ret>
    </assocfn>
</trait>
```

And turn it into this XML:

```xml
<trait>
    <name>Foo</name>
    <vis>pub</vis>
    <bounds>
        <const>
            <name>BAR</name>
            <type>usize</type>
        </const>
        <req>Baz</req>
    </bounds>
    <assoctype>
        <name>Baq</name>
        <bounds>
            <req>Qux</req>
        </bounds>
    </assoctype>
    <assocconst>
        <name>QUUX</name>
        <type>Self::Baq</type>
    </assocconst>
    <assocfn>
        <name>corge</name>
        <bounds>
            <type>
                <name>Grault</name>
            </type>
            <type>
                <name>Garply</name>
            </type>
        </bounds>
        <args>
            <arg>
                <name>waldo</name>
                <type>Grault</type>
            </arg>
        </args>
        <ret>Garply</ret>
    </assocfn>
</trait>
```

If you're asking, "Why? Why would you do this to us?" you're asking an excellent question.

And turn it into this XML:

```xml
<trait>
    <name>Foo</name>
    <vis>pub</vis>
    <bounds>
        <const>
            <name>BAR</name>
            <type>usize</type>
        </const>
        <req>Baz</req>
    </bounds>
    <assoctype>
        <name>Baq</name>
        <bounds>
            <req>Qux</req>
        </bounds>
    </assoctype>
    <assocconst>
        <name>QUUX</name>
        <type>Self::Baq</type>
    </assocconst>
    <assocfn>
        <name>corge</name>
        <bounds>
            <type>
                <name>Grault</name>
            </type>
            <type>
                <name>Garply</name>
            </type>
        </bounds>
        <args>
            <arg>
                <name>waldo</name>
                <type>Grault</type>
            </arg>
        </args>
        <ret>Garply</ret>
    </assocfn>
</trait>
```

If you're asking, "Why? Why would you do this to us?" you're asking an excellent question. I will not answer it.

The Horrors

WHAT

AURO NO PLEASE STOP

See the better question is, “Ooh, how does that work?”

AURO NO PLEASE STOP

See the better question is, “Ooh, how does that work?”

Let’s look at a very simple example.

IM BEGGING YOU DONT DO THIS

```
trait_xml! {
    <trait>
        <name>Foo</name>
        <vis>pub</vis>
        <unsafe/>
    </trait>
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @parse {
        input: [
            <trait>
                <name>Foo</name>
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @parsetrait {
        input: [
                <name>Foo</name>
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
        output: [],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_parse_name_ident! {
    @parse {
        input: [
                Foo</name>
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
        name: ,
        callback: [
            name: trait_xml_inner,
            rule: [@namecallback],
            args: [
                output: [],
            ],
        ],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_parse_name_ident! {
    @parseend {
        input: [
                </name>
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
        name: Foo,
        callback: [
            name: trait_xml_inner,
            rule: [@namecallback],
            args: [
                output: [],
            ],
        ],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @namecallback {
        input: [
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
        output: [],
        name: Foo,
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @parsetrait {
        input: [
                <vis>pub</vis>
                <unsafe/>
            </trait>
        ],
        output: [[name Foo]],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_parse_vis! {
    @parse {
        input: [
                pub</vis>
                <unsafe/>
            </trait>
        ],
        callback: [
            name: trait_xml_inner,
            rule: [@viscallback],
            args: [
                output: [[name Foo]],
            ],
        ],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @viscallback {
        input: [
                <unsafe/>
            </trait>
        ],
        output: [[name Foo]],
        vis: [pub],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @parsetrait {
        input: [
                <unsafe/>
            </trait>
        ],
        output: [[name Foo] [vis pub]],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @parsetrait {
        input: [</trait>],
        output: [[name Foo] [vis pub] [unsafe]],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @expand {
        output: [[name Foo] [vis pub] [unsafe]],
        vis: [],
        unsafe: ,
        name: ,
        gparams: [],
        tpbs: [],
        wc: [],
        assoc types: [],
        assoc consts: [],
        fns: [],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @expand {
        output: [[vis pub] [unsafe]],
        vis: [],
        unsafe: ,
        name: Foo,
        gparams: [],
        tpbs: [],
        wc: [],
        assoc types: [],
        assoc consts: [],
        fns: [],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @expand {
        output: [[unsafe]],
        vis: [pub],
        unsafe: ,
        name: Foo,
        gparams: [],
        tpbs: [],
        wc: [],
        assoc types: [],
        assoc consts: [],
        fns: [],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
trait_xml_inner! {
    @expand {
        output: [],
        vis: [pub],
        unsafe: unsafe,
        name: Foo,
        gparams: [],
        tpbs: [],
        wc: [],
        assoc types: [],
        assoc consts: [],
        fns: [],
    }
}
```

IM BEGGING YOU DONT DO THIS

```
pub unsafe trait Foo {}
```

The Horrors

why???

I WILL NOT APOLOGISE

There’s a few points I’m trying to make here.

I WILL NOT APOLOGISE

There's a few points I'm trying to make here.

1. Declarative macros are capable of a whole lot, actually

I WILL NOT APOLOGISE

There's a few points I'm trying to make here.

1. Declarative macros are capable of a whole lot, actually
2. You don't always need a proc macro
   - Simplify projects (don't need a separate crate)
   - Reduce dependencies and sometimes compile times (no `syn` and `quote`)

Review of `macro_rules!`

Review of `macro_rules!`

Why macros?

Why macros?

Turns out that metaprogramming is pretty cool actually

- Repeat lots of similar but not quite identical things

Why macros?

Turns out that metaprogramming is pretty cool actually

- Repeat lots of similar but not quite identical things
- Define new grammars that get expanded to valid Rust

Why macros?

Turns out that metaprogramming is pretty cool actually

- Repeat lots of similar but not quite identical things
- Define new grammars that get expanded to valid Rust
- Confuse everyone (including yourself!)

Review of `macro_rules!`

What is a `macro_rules!`?

What is a `macro_rules!`?

Declarative macros (the ones we care about for this presentation) are sort of like functions on the AST.

What is a `macro_rules!`?

Declarative macros (the ones we care about for this presentation) are sort of like functions on the AST.

We try to match on certain AST patterns (rules) against the input.

What is a `macro_rules!`?

Declarative macros (the ones we care about for this presentation) are sort of like functions on the AST.

We try to match on certain AST patterns (rules) against the input.

Rules are tried in order from top to bottom. This is the arbiter between ambiguous rules. Both `(foo bar)` and `(foo $next:tt)` match `foo bar`, but which one is chosen depends on their order in the macro def.

Review of `macro_rules!`

What are our AST node types, a.k.a. fragment specifiers?

Fragment specifier types

Rust has these fragment specifier types:

:item	:block	:stmt	:pat_param
:pat	:expr	:ty	:ident
:path	💕:tt💕	:meta	:lifetime
	:vis	:literal	

Each of these, except `:tt`, are subject to regular Rust parsing rules. Plus regex-like repetitions with `$( )?`, `$( )*`, and `$( )+`.

Fragment specifier types

Rust has these fragment specifier types:

:item	:block	:stmt	:pat_param
:pat	:expr	:ty	:ident
:path	💕:tt💕	:meta	:lifetime
	:vis	:literal	

Each of these, except `:tt`, are subject to regular Rust parsing rules. Plus regex-like repetitions with `$( )?`, `$( )*`, and `$( )+`.

There are also some limitations on what can come after certain fragment specifiers – follow set ambiguity restrictions

- `:expr` and `:stmt` can only be followed by `=>`, `,`, or `;`
- `:pat_param` can only be followed by `=>`, `,`, `=`, `|`, `if`, or `in`
- etc.

Review of `macro_rules!`

Fragment Specifier Composition

Composition

Fragment specifiers can be composed into other fragment specifiers. For example, a `:ident` and `:expr` can be composed into a `:stmt`.

Composition

Fragment specifiers can be composed into other fragment specifiers. For example, a `:ident` and `:expr` can be composed into a `:stmt`.

The reverse is **NOT** true.

```
:ident, :expr => :stmt  =  ✓
:stmt => :ident, :expr  =  ✗
```

Composition

Fragment specifiers can be composed into other fragment specifiers. For example, a `:ident` and `:expr` can be composed into a `:stmt`.

The reverse is **NOT** true.

```
:ident, :expr => :stmt  =  ✓
:stmt => :ident, :expr  =  ✗
```

However, `:tt` tends to be the most flexible option for these sorts of operations.

Composition

```
macro_rules! me_reaping {
    ($let:tt $lhs:tt $equal:tt $rhs:tt) => {
        // compose `:tt`s into a `:stmt`
        me_reaping!(@matchstmt $let $lhs $equal $rhs)
    };
    (@matchstmt $stmt:stmt) => {
        $stmt
    };
}

macro_rules! me_sowing {
    ($stmt:stmt) => {
        // attempt to break a `:stmt` back into component `:tt`s
        me_reaping!($stmt);
    }
}

fn main() {
    me_reaping!(let haha = "yes!!!");
    println!("{haha}");
    me_sowing!(let well_this = "sucks ):");
    println!("{well_this}");
}
```

Composition

That gives the following error message:

```
error: unexpected end of macro invocation
  --> src/main.rs:14:26
   |
 1 | macro_rules! me_reaping {
   | ----------------------- when calling this macro
...
14 | me_reaping!($stmt);
   |                  ^ missing tokens in macro arguments
   |
note: while trying to match meta-variable `$lhs:tt`
  --> src/main.rs:2:14
   |
 2 |     ($let:tt $lhs:tt $equal:tt $rhs:tt) => {
   |              ^^^^^^^
   |
```

Composition

That gives the following error message:

```
error: unexpected end of macro invocation
  --> src/main.rs:14:26
   |
 1 | macro_rules! me_reaping {
   | ----------------------- when calling this macro
...
14 | me_reaping!($stmt);
   |                  ^ missing tokens in macro arguments
   |
note: while trying to match meta-variable `$lhs:tt`
  --> src/main.rs:2:14
   |
 2 |     ($let:tt $lhs:tt $equal:tt $rhs:tt) => {
   |              ^^^^^^^
   |
```

This is definitely all the magic stuff we will do with token composition (lies!)

Main Restrictions

There's two main restrictions that I've come across that aren't super obvious at first:

Main Restrictions

There's two main restrictions that I've come across that aren't super obvious at first:

1. No significant whitespace

Main Restrictions

There's two main restrictions that I've come across that aren't super obvious at first:

1. No significant whitespace
2. No matching tokens (cannot do `$foo = $bar` or similar)

Main Restrictions

There's two main restrictions that I've come across that aren't super obvious at first:

1. No significant whitespace
2. No matching tokens (cannot do `$foo = $bar` or similar)

These are doable with proc macros, but those aren't the topic of today's talk.

Main Useful Patterns

Main Useful Patterns

Overview

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!
- Internal rules
  - these are branches that generally shouldn't be called by users

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!
- Internal rules
  - these are branches that generally shouldn't be called by users
- Incremental TT munchers
  - grabs chunks off the front end of the list of inputs

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!
- Internal rules
  - these are branches that generally shouldn't be called by users
- Incremental TT munchers
  - grabs chunks off the front end of the list of inputs
- Push-down accumulation
  - holds tokens in a list for later expansion

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!
- Internal rules
  - these are branches that generally shouldn't be called by users
- Incremental TT munchers
  - grabs chunks off the front end of the list of inputs
- Push-down accumulation
  - holds tokens in a list for later expansion
- TT bundling
  - boils down to grouping multiple tokens into a single list

Overview

There are ~~four~~six Big Lads of the Macropalypse:

- Recursion
  - of course macros can call themselves!
- Internal rules
  - these are branches that generally shouldn't be called by users
- Incremental TT munchers
  - grabs chunks off the front end of the list of inputs
- Push-down accumulation
  - holds tokens in a list for later expansion
- TT bundling
  - boils down to grouping multiple tokens into a single list
- Callbacks
  - workaround to let you pass the expansion of one macro as input to another*

Overview

Let’s look at each of these in turn, but first, disclaimers.

Overview

Let's look at each of these in turn, but first, disclaimers.

- You're going to hear and see, "You've seen this already in this presentation!" a lot.

Overview

Let's look at each of these in turn, but first, disclaimers.

- You're going to hear and see, "You've seen this already in this presentation!" a lot.
- Yes, these patterns (in combination) will let you parse just about anything.

Overview

Let's look at each of these in turn, but first, disclaimers.

- You're going to hear and see, "You've seen this already in this presentation!" a lot.
- ~~Yes, these patterns (in combination) will let you parse just about anything.~~ STOP STOP STOP
- Recursion is **THE** building block for macros using the aforementioned patterns, so for big inputs you may end up needing `#![recursion_limit = "a very big number"]`.

Overview

Let's look at each of these in turn, but first, disclaimers.

- You're going to hear and see, "You've seen this already in this presentation!" a lot.
- ~~Yes, these patterns (in combination) will let you parse just about anything.~~ STOP STOP STOP
- Recursion is **THE** building block for macros using the aforementioned patterns, so for big inputs you may end up needing `#![recursion_limit = "a very big number"]`. And a long time to compile.

Overview

Let's look at each of these in turn, but first, disclaimers.

- You're going to hear and see, "You've seen this already in this presentation!" a lot.
- ~~Yes, these patterns (in combination) will let you parse just about anything.~~ STOP STOP STOP
- Recursion is **THE** building block for macros using the aforementioned patterns, so for big inputs you may end up needing `#![recursion_limit = "a very big number"]`. And a long time to compile. And a lot of memory.

Overview

Let's look at each of these in turn, but first, disclaimers.

- Declarative macros can be (and often are) very difficult to debug.

Overview

Let's look at each of these in turn, but first, disclaimers.

- Declarative macros can be (and often are) very difficult to debug.
- Maintenance of big macros is... oh boy.

Overview

Let's look at each of these in turn, but first, disclaimers.

- Declarative macros can be (and often are) very difficult to debug.
- Maintenance of big macros is... oh boy.
- All that said, these patterns can be leveraged to simplify some things quite a lot.

Overview

Let's look at each of these in turn, but first, disclaimers.

- Declarative macros can be (and often are) very difficult to debug.
- Maintenance of big macros is... oh boy.
- All that said, these patterns can be leveraged to simplify some things quite a lot.
- This talk is mostly going to be showing how some pretty cursed stuff works, but at the end of the talk I'll give you a few ways to help "debug" macros and make writing them more manageable.

Main Useful Patterns

Recursion

Recursion my beloved

You've seen this already in this presentation!

This is the tool that every other pattern mentioned uses to work.

```
macro_rules! some_macro {
    /* pattern */ ⇒ {
        some_macro!(/* ... */)
    };
}
```

In function-like syntax, this is roughly equivalent to:

```
fn some_macro(input: Ast) → Ast {
    match input {
        /* pattern */ ⇒ some_macro(/* ... */)
    }
}
```

Main Useful Patterns

Internal Rules

Internal rules my beloved

You've seen this already in this presentation! Two slides prior, even!

As said previously, you generally don't want users calling these rules. Usually they're used as a helper to grab new kinds of tokens or to specify a certain mode of parsing.

```
macro_rules! some_macro {
    /* other rules */
    (@internalrule /* finish pattern */) ⇒ {
        /* expansion */
    };
}
```

Internal rules my beloved

Not all internal rules start with `@something`! Internal rules are just any rules that users are not expected to call but are used at some intermediate stage in macro expansion.

Useful in a couple ways

- Help avoid polluting crate namespace
  - Each internal rule could be its own macro, but those would also have to be marked with `#[macro_export]`
- Can be used to set “modes”
  - Useful for parsing context-sensitive things

Main Useful Patterns

Incremental TT munchers

Incremental TT munchers my beloved

You haven't seen this one already in this presentation! Surprise!

With these you typically look to grab an expected pattern including some inputs.

```
macro_rules! some_macro {
    () => { /* expansion */ };
    ($first:tt $($rest:tt)*) => {
        do_something_with!($first);
        /* expansion */
        some_macro!($($rest)*);
    };
}
```

As a function, this kinda looks like:

```
fn some_macro(input: Ast) -> Ast {
    if input.is_empty() {
        /* expansion */
    } else {
        do_something_with(input[0]);
        /* expansion */
        some_macro(input[1..])
    }
}
```

Main Useful Patterns

Push-down Accumulation

Push-down accumulation my beloved

This one hasn't been shown in this presentation yet!

Macros have to expand to a complete syntax element. Push-down accumulation is how you can allow for incomplete intermediate expansions that eventually form a complete expansion. For example:

```
macro_rules! some_macro {
    /* other rules */
    ([$name:ident $($t:ty)+]) ⇒ {
        pub struct $name($($t),+);
    }
}
```

Main Useful Patterns

TT Bundling

TT bundling my beloved

This one hasn't shown up yet either!

TT bundling is a sort of special case for composition, except this time we *can* actually reverse it!

Multiple tokens ⇒ [ ]-list (:tt)

```
macro_rules! bundle_and_unbundle {
    ($name:ident, $type:ty, $value:expr) => {
        bundle_and_unbundle! {
            @bundled [$name, $type, $value]
        }
    };
    (@bundled $bundle:tt) => {
        const _: &str = stringify!($bundle);
        bundle_and_unbundle! {
            @unbundle $bundle
        }
    };
    (@unbundle [$name:ident, $type:ty, $value:expr]) => {
        let $name: $type = $value;
    };
}
```

Main Useful Patterns

Callbacks

Callbacks my beloved

Very very generally, a callback looks something like this:

```
macro_rules! callback {
    ($callback:ident( $($args:tt)* )) ⇒ {
        $callback!( $($args)* )
    };
}
```

Callbacks my beloved

Very very generally, a callback looks something like this:

```
macro_rules! callback {
    ($callback:ident( $($args:tt)* )) ⇒ {
        $callback!( $($args)* )
    };
}
```

Provided you have a consistent framework for calling your macros, these let you:

- Reuse one macro in multiple places
- Form something like a call stack
- **Recursively** pass the expansion of one macro as input to another

These are great for being able to reuse one macro in multiple places.

Callbacks my beloved

Very very generally, a callback looks something like this:

```
macro_rules! callback {
    ($callback:ident( $($args:tt)* )) ⇒ {
        $callback!( $($args)* )
    };
}
```

Provided you have a consistent framework for calling your macros, these let you:

- Reuse one macro in multiple places
- Form something like a call stack
- **Recursively** pass the expansion of one macro as input to another

These are great for being able to reuse one macro in multiple places. As long as you have a consistent framework for calling your macros.

Debugging

That's the neat part

Kinda, at least

If you're defining items outside of functions, how do you debug things?

Kinda, at least

If you're defining items outside of functions, how do you debug things?

What do when no `println!`?

Kinda, at least

If you're defining items outside of functions, how do you debug things?

What do when no `println!`?

Introducing your new best friend:

```
const _: &str = stringify!($token);
// also
const _: &str = concat!($(stringify($tokens)),*);
```

Pretend println

You can see some residue from me debugging things and creating examples for documentation in `trait_xml_macro.rs`:

```
361     // End of trait definition
362     (
363         @parsetrait {
364             input: [</trait>],
365             output: $outtoks:tt,
366         }
367     ) ⇒ {
368         // const _: &str = stringify!($outtoks);
369         $crate::trait_xml_inner! {
370             @expand {
371                 output: $outtoks,
372                 vis: [],
373                 unsafe: ,
374                 name: ,
375                 gparams: [],
376                 tpbs: [],
377                 wc: [],
378                 assoc types: [],
379                 assoc consts: [],
380                 fns: [],
381             }
382         }
383     };
```

No rules expected the token...

“But Auro! My macro just plain doesn’t work! I can’t use `const _`.”

Yes you can.

```
macro_rules! this_fails_somehow {
    // a bunch of rules up here...
    // ...and then at the end:
    ($($all:tt)*) ⇒ {
        const _: &str = concat!($(stringify!($all)),*);
    };
}
```

This shows you the input as a string so you can try and figure out what’s going wrong.

It’s also only matched if no other branch matches. But...

No rules expected the token...

"But Auro! My macro just plain doesn't work! I can't use `const _`."

Yes you can.

```
macro_rules! this_fails_somehow {
    // a bunch of rules up here...
    // ...and then at the end:
    ($($all:tt)*) ⇒ {
        const _: &str = concat!($(stringify!($all)),*);
    };
}
```

This shows you the input as a string so you can try and figure out what's going wrong.

It's also only matched if no other branch matches. But...You still have to figure out why it's not matching.

But how did it get there???

Sometimes it's hard to figure out just how a macro ended up expanding the way it did. Well, thankfully, we have a tool for that too! It's not super good, but it does its job.
This new acquaintance is the unstable flag `-Z trace_macros`.

But how did it get there???

Remember `bundle_and_unbundle!` from earlier? Let's `cargo check` that with `-Z trace_macros`.

```
note: trace_macro
  --> src/main.rs:19:2
   |
19 | /     bundle_and_unbundle! {
20 | |         foo, u8, 0
21 | |     }
   | |_____^
   |
   = note: expanding `bundle_and_unbundle! { foo, u8, 0 }`
   = note: to `bundle_and_unbundle! { @ bundled [foo, u8, 0] }`
   = note: expanding `bundle_and_unbundle! { @ bundled [foo, u8, 0] }`
   = note: to `const _ : & str = stringify! ([foo, u8, 0]) ; bundle_and_unbundle!
           { @ unbundle [foo, u8, 0] }`
   = note: expanding `bundle_and_unbundle! { @ unbundle [foo, u8, 0] }`
   = note: to `let foo : u8 = 0 ;`
```

No rules expected the token...

Another thing you can do to keep `error: no rules expected the token` from coming up is by just... making rules that expect the token/those tokens.

No rules expected the token...

Another thing you can do to keep `error: no rules expected the token` from coming up is by just... making rules that expect the token/those tokens.

My XML parsing macros do this a bunch - if you give them an invalid input, a lot of the time it'll expand to a `compile_error!`, e.g. in `lifetime.rs`:

```
342     (
343         @parse {
344             input: [$unx:tt$($rest:tt)*],
345             lifetime: $($lt:lifetime)?,
346             bounds: $boundstoks:tt,
347             callback: [
348                 name: $callback:path,
349                 rule: $ruletoks:tt,
350                 args: $argstoks:tt,
351             ],
352         }
353     ) ⇒ {
354         compile_error!(
```

Other things

Some other suggestions to help you on your way (that sound a lot like general programming advice):

- Use descriptive names for rules, helper tokens, and fragments
- Don’t worry about excessive complexity in a single rule – just try to keep the depth of recursion down if you can
- Don’t be afraid to make another macro, especially if it can be reused in other places
- If you need more steps to finish parsing, add them. Nobody needs to see all your internal rules but you (:

That's all!

Materials

The materials for this talk are available on GitHub and GitLab at `AuroransSolis/rustconf-2023`.