

Coccinelle for Rust

<https://gitlab.inria.fr/coccinelle/coccinelleforrust.git>

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 - Rust is 1.6 MLOC.
 - The Linux kernel is 23 MLOC.
 - Collateral evolutions: a change in an API requires changes in all clients.
- Provide a transformation language that builds on developer expertise.
- Changes + developer familiarity = (semantic) patches

An example change (Rust repository)

```
commit d822b97a27e50f5a091d2918f6ff0ffd2d2827f5
Author: Kyle Matsuda <kyle.yoshio.matsuda@gmail.com>
Date:   Mon Feb 6 17:48:12 2023 -0700
```

change usages of type_of to bound_type_of

```
diff --git a/compiler/rustc_borrowck/src/diagnostics/conflict_errors.rs b/compiler/.../conflict_errors.rs
@@ -2592,4 +2592,4 @@ fn annotate_argument_and_return_for_borrow(
    } else {
-        let ty = self.infcx.tcx.type_of(self.mir_def_id());
+        let ty = self.infcx.tcx.bound_type_of(self.mir_def_id()).subst_identity();
        match ty.kind() {
            ty::FnDef(_, _) | ty::FnPtr(_) => self.annotate_fn_sig(
diff --git a/compiler/rustc_borrowck/src/diagnostics/mod.rs b/compiler/.../mod.rs
@@ -1185,4 +1185,4 @@ fn explain_captures(
    matches!(tcx.def_kind(parent_did), rustc_hir::def::DefKind::Impl { .. })
        .then_some(parent_did)
-        .and_then(|did| match tcx.type_of(did).kind() {
+        .and_then(|did| match tcx.bound_type_of(did).subst_identity().kind() {
            ty::Adt(def, ..) => Some(def.did()),
        ...
```

136 files changed, 385 insertions(+), 262 deletions(-)

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    ...
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Creating a semantic patch: Step 1: remove irrelevant code

```
- let ty = self.infcx.tcx.type_of(self.mir_def_id())
+ let ty = self.infcx.tcx.bound_type_of(self.mir_def_id()).subst_identity()

- .and_then(|did| match tcx.type_of(did) kind() {
+ .and_then(|did| match tcx.bound_type_of(did).subst_identity() kind() {
```

Creating a semantic patch: Step 2: pick a typical example

@@

@@

```
- self.infcx.tcx.type_of(self.mir_def_id())  
+ self.infcx.tcx.bound_type_of(self.mir_def_id()).subst_identity()
```

Creating a semantic patch: Step 3: abstract over subterms using metavariables

```
@@  
expression tcx, arg;  
@@  
  
- tcx.type_of(arg)  
+ tcx.bound_type_of(arg).subst_identity()
```

Creating a semantic patch: Step 3: abstract over subterms using metavariables

```
@@  
expression tcx, arg;  
@@  
  
- tcx.type_of(arg)  
+ tcx.bound_type_of(arg).subst_identity()
```

Updates over 200 call sites.

An outlier

```
let (shim_size, shim_align, _kind) = ecx.get_alloc_info(alloc_id);
+ let def_ty = ecx.tcx.bound_type_of(def_id).subst_identity();
let extern_decl_layout =
-     ecx.tcx.layout_of(ty::ParamEnv::empty().and(ecx.tcx.type_of(def_id))).unwrap();
+     ecx.tcx.layout_of(ty::ParamEnv::empty().and(def_ty)).unwrap();
if extern_decl_layout.size != shim_size || extern_decl_layout.align.abi != shim_align {
    throw_unsup_format!(
        "`extern` static `{name}` from crate `{krate}` has been declared \
```

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if extern_decl_layout.size != shim_size || extern_decl_layout.align.abi != shim_align {
    throw_unsup_format!(
        "`extern` static `{name}` from crate `{krate}` has been declared \
```

The developer has created a new name to avoid a long line.

- Could address it manually.
- Could create a rule for the special case of nested function call contexts (probably not worth it for one case).

An alternate semantic patch

```
@@  
expression tcx, arg;  
@@  
  
    tcx.  
-   type_of(arg)  
+   bound_type_of(arg).subst_identity()
```

Putting tcx in the context ensures any comments will be preserved.

A refinement

```
@@
TyCtxt tcx;
expression arg;
@@

tcx.
-   type_of(arg)
+   bound_type_of(arg).subst_identity()
```

Specifying the type of *tcx* protects against changing other uses of *type_of*.

An example: change in context

```
commit 1ce80e210d152619caa99b1bc030f57a352b657a
Author: Oliver Scherer <oli-obk@users.noreply.github.com>
Date: Thu Feb 16 09:25:11 2023 +0000
```

Allow ``LocalDefId`` as the argument to ``def_path_str``

```
diff --git a/compiler/rustc_borrowck/src/lib.rs b/compiler/rustc_borrowck/src/lib.rs
@@ -124,3 +124,3 @@ pub fn provide(providers: &mut Providers) {
     fn mir_borrowck(tcx: TyCtxt<'_, def: LocalDefId) -> &BorrowCheckResult<'_> {
         let (input_body, promoted) = tcx.mir_promoted(def);
-        debug!("run query mir_borrowck: {}", tcx.def_path_str(def.to_def_id()));
+        debug!("run query mir_borrowck: {}", tcx.def_path_str(def));
diff --git a/compiler/rustc_hir_analysis/src/check/check.rs b/compiler/rustc_hir_analysis/src/check/check.rs
@@ -494,5 +494,5 @@ fn check_item_type(tcx: TyCtxt<'_, id: hir::ItemId) {
     debug!(
         "check_item_type(it.def_id={:?}, it.name={})",
         id.owner_id,
-        tcx.def_path_str(id.owner_id.to_def_id())
+        tcx.def_path_str(id.owner_id)
     );
...

```

18 files changed, 68 insertions(+), 54 deletions(-)

An example: change in context

Want to drop `.to_def_id()` but only in an argument to `tcx.def_path_str`:

```
@@
expression tcx, arg;
@@
-      tcx.def_path_str(arg.to_def_id())
+      tcx.def_path_str(arg)
```

Updates 48 call sites in 18 files.

An example: multiple cases

commit 298ae8c721102c36243335653e57a7f94e08f94a

Author: Michael Goulet <michael@errs.io>

Date: Wed Feb 22 22:23:10 2023 +0000

Rename `ty_error_with_guaranteed` to `ty_error`, `ty_error` to `ty_error_misc`

diff --git a/compiler/rustc_borrowck/src/region_infer/opaque_types.rs b/compiler/.../opaque_types.rs

@@ -156,3 +156,3 @@ pub(crate) fn infer_opaque_types(
 });

- prev.ty = infcx.tcx.ty_error_with_guaranteed(guar);

+ prev.ty = infcx.tcx.ty_error(guar);

}

@@ -248,3 +248,3 @@ fn infer_opaque_definition_from_instantiation(
 if let Some(e) = self.tainted_by_errors() {

- return self.tcx.ty_error_with_guaranteed(e);

+ return self.tcx.ty_error(e);

}

...

diff --git a/compiler/rustc_hir_analysis/src/astconv/mod.rs b/compiler/rustc_hir_analysis/src/astconv/mod.rs

@@ -429,2 +429,2 @@ fn provided_kind(
 self.inferred_params.push(ty.span);

- tcx.ty_error().into()

+ tcx.ty_error_misc().into()

32 files changed, 121 insertions(+), 140 deletions(-)

An example: multiple cases

Two changes:

- From *ty_error_with_guaranteed* to *ty_error* (1 argument)
- From *ty_error* to *ty_error_misc* (no arguments)

```
@@  
expression tcx, arg;  
@@  
- tcx.ty_error_with_guaranteed(arg)  
+ tcx.ty_error(arg)
```

```
@@  
expression tcx, arg;  
@@  
- tcx.ty_error()  
+ tcx.ty_error_misc()
```

An example: searching for variants

```
commit f3f9d6dfd92dfaeb14df891ad27b2531809dd734
Author: Eduard-Mihai Burtescu <edy.burt@gmail.com>
Date:   Fri Jun 14 00:48:52 2019 +0300
```

Unify all uses of 'gcx' and 'tcx'.

```
diff --git a/src/librustc/infer/error_reporting/mod.rs b/src/librustc/infer/error_reporting/mod.rs
@@ -460,6 +460,6 @@ impl<'gcx, 'tcx> Printer<'gcx, 'tcx> for AbsolutePathPrinter<'gcx, 'tcx> {
     type DynExistential = !;
     type Const = !;

-    fn tcx<'a>(&'a self) -> TyCtxt<'gcx, 'tcx> {
+    fn tcx<'a>(&'a self) -> TyCtxt<'tcx> {
         self.tcx
     }
@@ -1977,4 +1976,4 @@ pub fn enter_global<'gcx, F, R>(gcx: &'gcx GlobalCtxt<'gcx>, f: F) -> R
     pub unsafe fn with_global<F, R>(f: F) -> R
     where
-        F: for<'gcx, 'tcx> FnOnce(TyCtxt<'gcx, 'tcx>) -> R,
+        F: for<'tcx> FnOnce(TyCtxt<'tcx>) -> R,
     {
```

341 files changed, 3109 insertions(+), 3327 deletions(-)

An example: searching for variants

A first attempt:

```
@rule type@  
@@  
- TyCtxt<'gcx', 'tcx'  
+ TyCtxt<'tcx'
```

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@rule type@  
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+ TyCtxt<'tcx>
```

This does part of the work, but some change sites are overlooked:

- `DepNodeParams<'gcx, 'tcx>`
- `TyCtxt<'tcx, 'tcx>, TyCtxt<'_, ' _>`

An example: searching for variants

A first attempt:

```
@rule type@  
@@  
- TyCtxt<'gcx, 'tcx>  
+ TyCtxt<'tcx>
```

This does part of the work, but some change sites are overlooked:

- *DepNodeParams*<'gcx, 'tcx>
- *TyCtxt*<'tcx, 'tcx>, *TyCtxt*<'_, '_>
- And others?

An example: searching for variants

A more general attempt:

```
@rule type@  
identifier Ty;  
@@  
- Ty<'gcx', 'tcx'  
+ Ty<'tcx>
```

An example: searching for variants

A more general attempt:

```
@rule type@  
identifier Ty;  
@@  
- Ty<'gcx', 'tcx>  
+ Ty<'tcx>
```

How to find other change sites, like `TyCtxt<'tcx', 'tcx>`, `TyCtxt<'_, '_>`:

- Want to change all uses of types that are somewhere used with `'gcx`.

An example: searching for variants

A more general attempt:

```
@r type@
identifier Ty;
@@
- Ty<'gcx', 'tcx>
+ Ty<'tcx>

@rule type@
identifier r.Ty;
@@
(
- Ty<'tcx', 'tcx>
+ Ty<'tcx>
|
- Ty<'_', ' _>
+ Ty<' _>
)
```

An example: using more metavariables

A more general attempt:

```
@r type@
identifier Ty;
@@
- Ty<'gcx, 'tcx>
+ Ty<'tcx>

@rule type@
identifier r.Ty;
lifetime a, b;
@@
- Ty<a, b>
+ Ty<b>
```

Summary: Features seen so far

- Semantic patches:
Patch-like transformation specification, abstracted using metavariables.
- Multiple rules/rule ordering.
- Inheritance.
- Disjunctions.
- Typed metavariables

All of these features are implemented!

Future features: . . . in parameter lists

One parameter case: (supported already)

```
@@
identifier f, P, p;
type T1, T2;
@@
- f<P: T1>(p: P) -> T2
+ f(p: impl T1) -> T2
  { ... }
```

Future features: . . . in parameter lists

Multiple parameter case:

```
@@
identifier f, P, p;
type T1, T2;
@@
```

```
  f
-  <P: T1>
    (... ,
-    p: P
+    p: impl T1
    , ...)
{ ... }
```

Future features: . . . in parameter lists

Multiple parameter case:

```
@@
identifier f, P, p;
type T1, T2;
@@

  f
-  <P: T1>
    (... ,
-    p: P
+    p: impl T1
    , ...)
  { ... }
```

Likewise for function arguments.

Future features: . . . across control-flow paths

A sequence of statements: (works already)

@@

```
identifier e;  
expression rt;
```

@@

```
- let mut e = tokio_executor::enter().unwrap();  
- e.block_on(rt.shutdown_on_idle());  
+ rt.shutdown_on_idle();
```

Future features: . . . across control-flow paths

The statements may not be contiguous:

```
@@
identifier e;
expression rt;
@@
-   let mut e = tokio_executor::enter().unwrap();
-   ...
-   e.block_on(rt.shutdown_on_idle());
+   rt.shutdown_on_idle();
```

Future features: . . . across control-flow paths

A safer variant:

```
@@
identifier e;
expression rt;
expression e1;
@@
-   let mut e = tokio_executor::enter().unwrap();
-   ... when != e = e1
-   e.block_on(rt.shutdown_on_idle());
+   rt.shutdown_on_idle();
```

Future features: Isomorphisms

Isomorphism: A rewrite on the semantic patch to match and transform essentially equivalent code.

Examples for C:

- Explicitly defined isomorphisms:

```
Expression  
@ not_ptr1 @  
expression *X;  
@@  
!X => X == NULL
```

```
Expression  
@ paren @  
expression E;  
@@  
(E) => E
```

- Implicit isomorphisms
 - On a function definition the return type, *static*, *inline*, etc. can be omitted.
 - *e1 = e2* also matches a variable initialization.

Future features: An isomorphism for Rust

For *shutdown_on_idle*, the code is always written as:

```
let mut e = tokio_executor::enter().unwrap();  
e.block_on(rt.shutdown_on_idle());
```

Future features: An isomorphism for Rust

For *shutdown_on_idle*, the code is always written as:

```
let mut e = tokio_executor::enter().unwrap();  
e.block_on(rt.shutdown_on_idle());
```

But it could be written as:

```
tokio_executor::enter().unwrap().block_on(rt.shutdown_on_idle());
```

Future features: An isomorphism for Rust

@@

expression rt;

@@

- *tokio_executor::enter().unwrap().block_on(rt.shutdown_on_idle());*

+ *rt.shutdown_on_idle();*

Future features: An isomorphism for Rust

```
@@  
expression rt;  
@@  
- tokio_executor::enter().unwrap().block_on(rt.shutdown_on_idle());  
+ rt.shutdown_on_idle();
```

Potential implicit isomorphisms:

- Introduce *let* to name all possible subterms.
- Introduce *...* and *when* to allow other code between the *let* and the use.

Future features: An isomorphism for Rust

```
@@  
expression rt;  
@@  
- tokio_executor::enter().unwrap().block_on(rt.shutdown_on_idle());  
+ rt.shutdown_on_idle();
```

Potential implicit isomorphisms:

- Introduce *let* to name all possible subterms.
- Introduce *...* and *when* to allow other code between the *let* and the use.
- **Caveat:** Complexity may drastically increase if the *...* crosses a loop.

Future features: Another isomorphism for Rust

Developers can use *use* with more or less information.

One example:

```
- use std::sync::Mutex;  
+ use crate::loom::sync::Mutex;
```

Another example:

```
-use std::sync::{Arc, Mutex};  
+use crate::loom::sync::{Arc, Mutex};
```

Options:

- Specify one change at a time?
- Merge changed code?
- Merge changed code with unchanged code?

Some more Coccinelle future features

- Position variables.
- Script code.
- Constraints on metavariables.
- Fresh identifiers.
- `*` for matching without transformation.

Some Coccinelle internals

Input: Parsing provided by Rust Analyzer.

- Used both for Rust code and for semantic patch code.
- Will provide type inference, when needed (currently, loses concurrency).

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Input: Parsing provided by Rust Analyzer.

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Output: Pretty printing provided by *rustfmt*.

- To avoid problems with code not originally formatted with *rustfmt* (or formatted with a different version), the *rustfmted* changes are dropped back into the original code.
- Preserves comments and whitespace in the unchanged part of the code.

In the middle:

- Wrap Rust code and semantic patch code, eg to indicate metavariables.
- Match semantic patch code against Rust code, to collect change sites and metavariable bindings.
- On a successful match, apply the changes, instantiated according to the metavariable bindings, reparse, and repeat with the next rule.

Practical issues

Usage: main [OPTIONS] --coccifile <COCCIFILE> --targetpath <TARGETPATH>

Options:

<i>-c, --coccifile <COCCIFILE></i>	<i>Path of Semantic Patch File path</i>
<i>-t, --targetpath <TARGETPATH></i>	<i>Path of Rust Target file/folder path</i>
<i>-o, --output <OUTPUT></i>	<i>Path of transformed file path</i>
<i>-r, --rustfmt-config <RUSTFMT_CONFIG></i>	<i>rustfmt config file path [default: rustfmt.toml]</i>
<i>-i, --ignore <IGNORE></i>	<i>[default:]</i>
<i>-d, --debug-cocci</i>	
<i> --apply</i>	
<i> --suppress-diff</i>	
<i> --suppress-formatting</i>	
<i> --no-parallel</i>	
<i>-h, --help</i>	<i>Print help</i>
<i>-V, --version</i>	<i>Print version</i>

Conclusion

- Transformation on atomic terms completed (expressions, types, etc).
- Transformation on terms connected by a control-flow path (...) in progress.
- Small-scale testing has been done:
 - Replicating real changes on real Rust code.
- Patchparse extended to Rust, to find test cases at a larger scale.

- Transformation on atomic terms completed (expressions, types, etc).
- Transformation on terms connected by a control-flow path (...) in progress.
- Small-scale testing has been done:
 - Replicating real changes on real Rust code.
- Patchparse extended to Rust, to find test cases at a larger scale.

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