Beyond Notations: Hygienic Macro Expansion for Theorem Proving Languages

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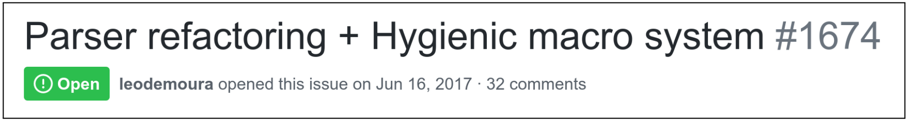
It's been a long time coming...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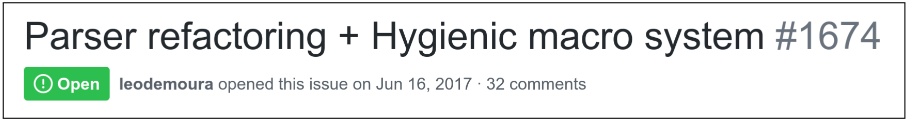
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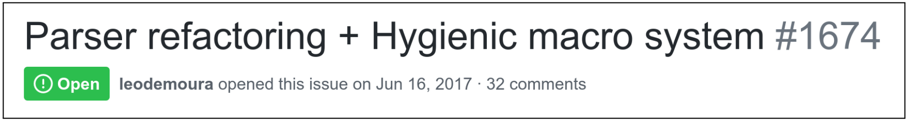
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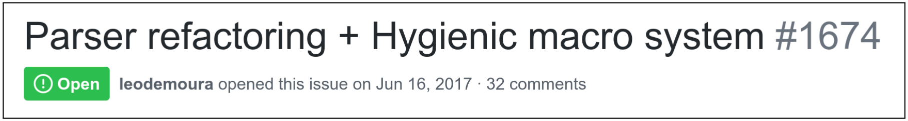
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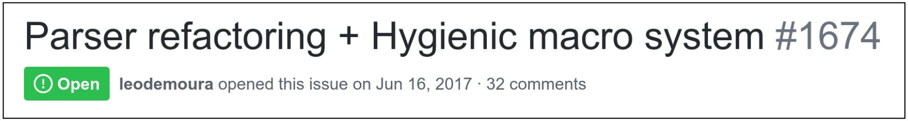
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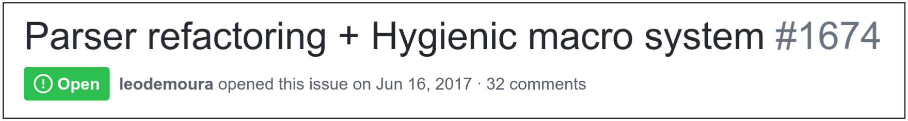
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What issues could be that important?

Issues with existing syntax sugar systems

- Restricted to term level

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Notation "\sum_ ( i <- r ) F"         := (\big[addn/0]_(i <- r) F).
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- Low-level might exist, but separate system!

```
@[user_notation] meta def format_macro (_ : parse $ tk "format!") (s : string) :
  parser pexpr := ...
```

A unified frontend system

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Notations *Term* $\rightarrow$ *Term*

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Elaborators $\quad Surf \to Core$

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elab "∃" b:term "," P:term : term =>
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Equal hygiene guarantees for all levels

Hygiene

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macro "elab" ... => do
  ...;
  `(@[$elabAttr] def elabFn (stx : Syntax) : $type := match_syntax stx with ...)
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⇒ Hygienic macros introduce scopes!

Hygiene system

Main inspiration: *Binding as Sets of Scopes*, Matthew Flatt, POPL'16

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Streamlined & optimized for slightly simpler macro system:
no local macros, no mutual recursion between decls and macros

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In essence:

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`(def elabFn{} (stx{} : Syntax{Lean.Syntax}) ...)
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def elabFn.23{} (stx.23{} : Syntax.23{Lean.Syntax}) ...
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(sequences of tags become important in macro-macros!)

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(sequences of tags become important in macro-macros!)

Both actually implemented inside the `` `(...) `` macro!

Adapted name resolution

1. If tagged name is in local context, use it

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... (stx.23{} : ...) := match_syntax stx.23{} ...
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3. Otherwise fail

Examples: Lean 4 elaborator

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```
syntax "if" optIdent term "then" term "else" term : term
macro_rules
| `(if $h : $cond then $t else $e) => `(dite $cond (fun $h => $t) (fun $h => $e))
| `(if $cond then $t else $e)      => `(ite $cond $t $e)
```

Examples: Lean 4 elaborator

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  τ ← whnf τ;
  match τ.getAppFn with
  | Expr.const I _ _ => do
    ctors ← getCtors I;
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    | [c] => do
      stx ← `($(mkCTermId c) $(getSepElems args.getArgs)*);
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  ... -- error handling
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Examples: simple web server

```
import Webserver

GET / => redirect "/greet/stranger"

GET /greet/{name} => write
  <html>
    <h1>Hello, {name}!</h1>
  </html>

def main : IO Unit := do
  hIn ← IO.stdin;
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  Webserver.run hIn hOut
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https://leanprover.github.io/talks/PLDI20

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Lean 3 helper for proving injectivity of constructors:

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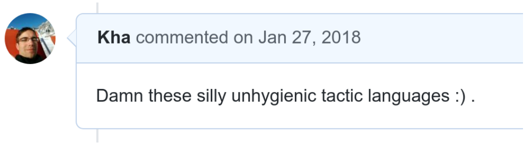

Kha commented on Jan 27, 2018

Damn these silly unhygienic tactic languages :) .

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macro introH : tactic => `(intro $(mkIdent `h))
lemma ... by introH; exact h  -- works!
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Thank you!