Delimited overloading

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-  Dany Maslowsky and
-  Julie De Pril

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Outline

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Basic use

```
Float.(1 + x * f 4)
Float.(4 * u**2 / sqrt(abs alpha))
Hashtbl.(h.(key) <- x)
```

- ☞ Literals, functions, and "constant constructions" substitution.
- ☞ Better readability.

```
Big_int.(if x > 0 then x else 0)
```

- ☞ Can use the usual comparison operators.

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Int32.(4 + a.(Int.(1 + x)))
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- ☞ Embedded overloadings.

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Static checks & simple optimizations

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Num.("12345678" + x)
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☞ Compile time check.

If one writes `Num.("a12")`, when compiling, the following error is issued

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Parse error:  The string "a12" does not represent a
valid Num.
Preprocessing error on file foo.ml
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Float.((x+1)**2)
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☞ Simple optimization. The whole expression is substituted by (binding introduced only if needed):

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let tmp = x +. 1.0 in tmp *. tmp
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Complex numbers

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Complex.(let z = 3 + 2 I in sin(z * z))
```

- ☞ "I" notation.
- ☞ Let binding are allowed.
- ☞ Complex functions like `sin`, `cos`,... are inlined.

For example,

```
Complex.((2 + 3 I) * f x)
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is turned into

```
let tmp = f x in
{ Complex.re = (tmp.Complex.re *. 2.0) -.
               (tmp.Complex.im *. 3.0);
  Complex.im = (tmp.Complex.re *. 3.0) +.
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Summary

`pa_do.cmo` provides overloadings for

`Int`	`Float`	`Hashtbl`
`Int32`	`Complex`	`String`
`Int64`		
`Nativeint`		

`pa_do_nums.cmo` provides overloadings for

`Num`
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Concrete syntax v.s. API

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In the source file	In a separate file
Must be repeated in each file	Can be bundled with a library
No possibility of overloading general expressions	One can overload general expressions and perform some optimizations

Demo

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Demo

"Set of overloadings"

Constructions that can be overloaded:

literals

```
'x
a.(i)
a.(i) <- x
a.[i]
a.[i] <- x
a.{i}
a.{i} <- x
a := x
a <- x
a.p
```

functions & operators overloadings

general substitutions

How to overload one's own module (1/2)

```
module Foo :
sig
  type t
  val of_int :  int -> t
  val compare :  t -> t -> int
  val add :  t -> t -> t
  val mul :  t -> t -> t
end
```

Overloading with the concrete syntax:

- int literals: `OVERLOAD_INT Foo (of_int)`
- comparison: `OVERLOAD_COMPARISON Foo (compare)`
- functions:

  `OVERLOAD Foo ( ( + ) -> add; ( * ) -> mul )`

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How to overload one's own module (2/2)

Remarks

- If `Foo` implements all standard functions `add`, `sub`, `mul`, `div` and `neg` (unary negation):
  ☞ `OVERLOAD_ARITHMETIC Foo`.

- If a new module is implemented:

```
module Special_foo =
sig
  include Foo
  val sub : t -> t -> t
end
```

  ☞ `OVERLOAD Special_foo inherit Foo`
  ☞ `OVERLOAD Special_foo ( ( - ) -> sub )`

How to overload one's own module (2/2)

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Some more examples

Basin of attraction of Newton's method for $z^3 = 1$.

```
Complex.(
  let z = ref z0 in
  for i = Int.(1) to niter do
    z := (2 * !z + 1 / !z**2) / 3
  done;
  if abs(!z - root0) <= r then Some color0
  ... )
```

Let $D = 1.7$. If $p = [p_0; \ldots; p_n]$ represents the polynomial $\sum_{i=0}^{n} p_i z^i$, its norm is (here) defined by $\|p\| := \sum_{i=0}^{n} |p_i| D^i$

```
let domain = Interval.(17 / 10)
let norm p = Interval.(List.fold_right (fun c n ->
                          abs c + domain * n) p 0)
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Priority and associativity of operators

`pa_infix.cmo`

Concrete syntax:

```
INFIX ( %+ ) RIGHTA HIGHER (+)
INFIX ( ^* ) LEVEL (+)
PREFIX ( /+/ )
POSTFIX ( /// ) LEVEL ( ! )
```

API: treat `a = b |> c` as `a = (b |> c)` and replace `x |> f` by `f x`:

```
open Pa_infix
module L = Level
let l = L.binary (L.Higher L.comparison) ~assoc:L.LeftA in
let expr x y _loc = <:expr< $y$ $x$ >> in
infix "|>" ~expr l
```

Outline

Collaboration with Delimited Overloading

```
DEFINE NEWTON(M,x) = M.( (2 * x + 1 / x**2) / 3 )
```

Use it as

```
NEWTON(Float, r)
NEWTON(Complex, z)
```

- ☞ Poor man defunctorizer;
- ☞ Contrarily to functors, requalifies constants.

Better error reporting

```
DEFINE A(x) =
  let s = ref 0.0 in
  for i = 1 to x do
    s := !s + float i
  done;
  s

let () = print_float(A(100))
```

With the standard macros:

```
File "...", line 8, characters 21-27:
This expression has type float but is here used with type
int
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With Delimited Overloading macros:

```
File "...", line 8, characters 21-27:
Expanding of the macro "A" at the previous location yields
the error:
File "...", line 4, characters 11-13:
This expression has type float but is here used with type
int
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Outline

Optimization for complex operators

```
Complex.((2 + 3 I) * f x)
```

1. Classify subexpressions according to

```
type t =
  | Zero
  | Re of Ast.expr
  | Im of Ast.expr
  | Cplx of Ast.expr * Ast.expr
  | Unknown of Ast.expr
```

2. Specialize complex functions, introducing bindings as needed.

Embedded overloading (1/3)

$$\texttt{X.(e)} \mapsto \sigma_{\texttt{X}}\texttt{(e)}$$

where $\sigma_{\texttt{X}}$: *expression* $\longrightarrow$ *expression*

Problem encountered:

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Int32.(a.(Int.(0)) <- 7 + x)
```

↓ apply $\sigma_{\texttt{Int}}$; here $\sigma_{\texttt{Int}}\texttt{(0)} = \texttt{0}$

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↓ apply $\sigma_{\texttt{Int32}}$

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a.(0l) <- Int32.add 7l x
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Problem!

☞ Protection of already overloaded expressions

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a.(01) <- Int32.add 71 x
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Embedded overloading (2/3)

Requirements:

- $\sigma_{\texttt{Int}}(0)$ must be a valid expression;
- it must not change the meaning of the program nor its performance;
- locations must not be affected (for correct error reporting).

Solution:

$$\texttt{X.(e)} \mapsto \texttt{p}(\sigma_{\texttt{X}}(\texttt{e}))$$

where p is an undeclared function name!

☞ p is removed by the surrounding overloading $\Rightarrow$ global flag to know whether to insert π.
☞ **external** p : $\alpha \to \alpha$ = "%identity" forbid some optimizations to take place!

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Embedded overloading (3/3)

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↓ $\texttt{Int.(0)} = \texttt{p}(\sigma_{\texttt{Int}}(0)) = \texttt{p(0)}$

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Int32.(a.(p(0)) <- 7 + x)
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```
p(a.(0) <- Int32.add 7l x)
```

OK!

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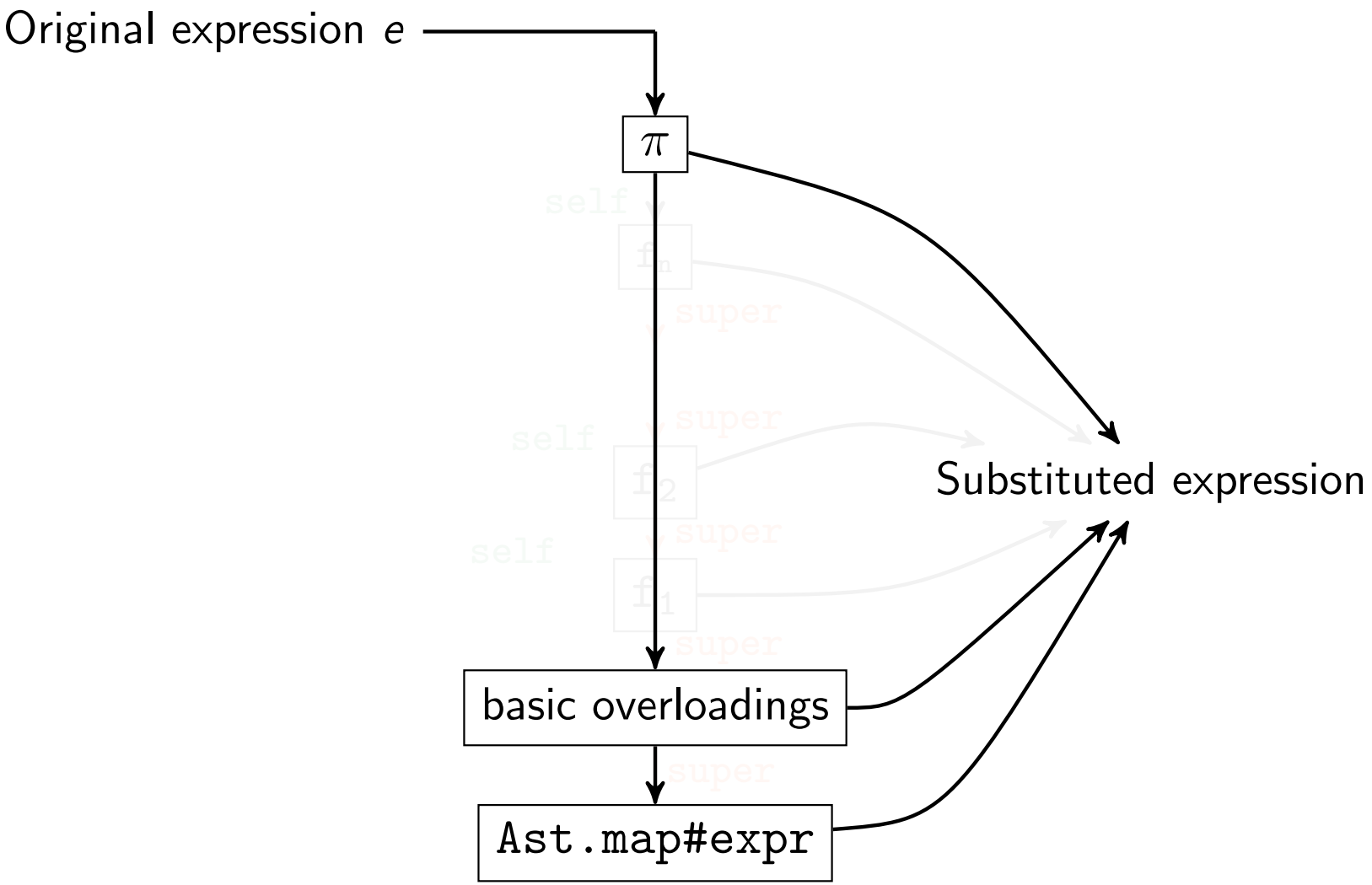
General substitution of expressions `X.(e)`



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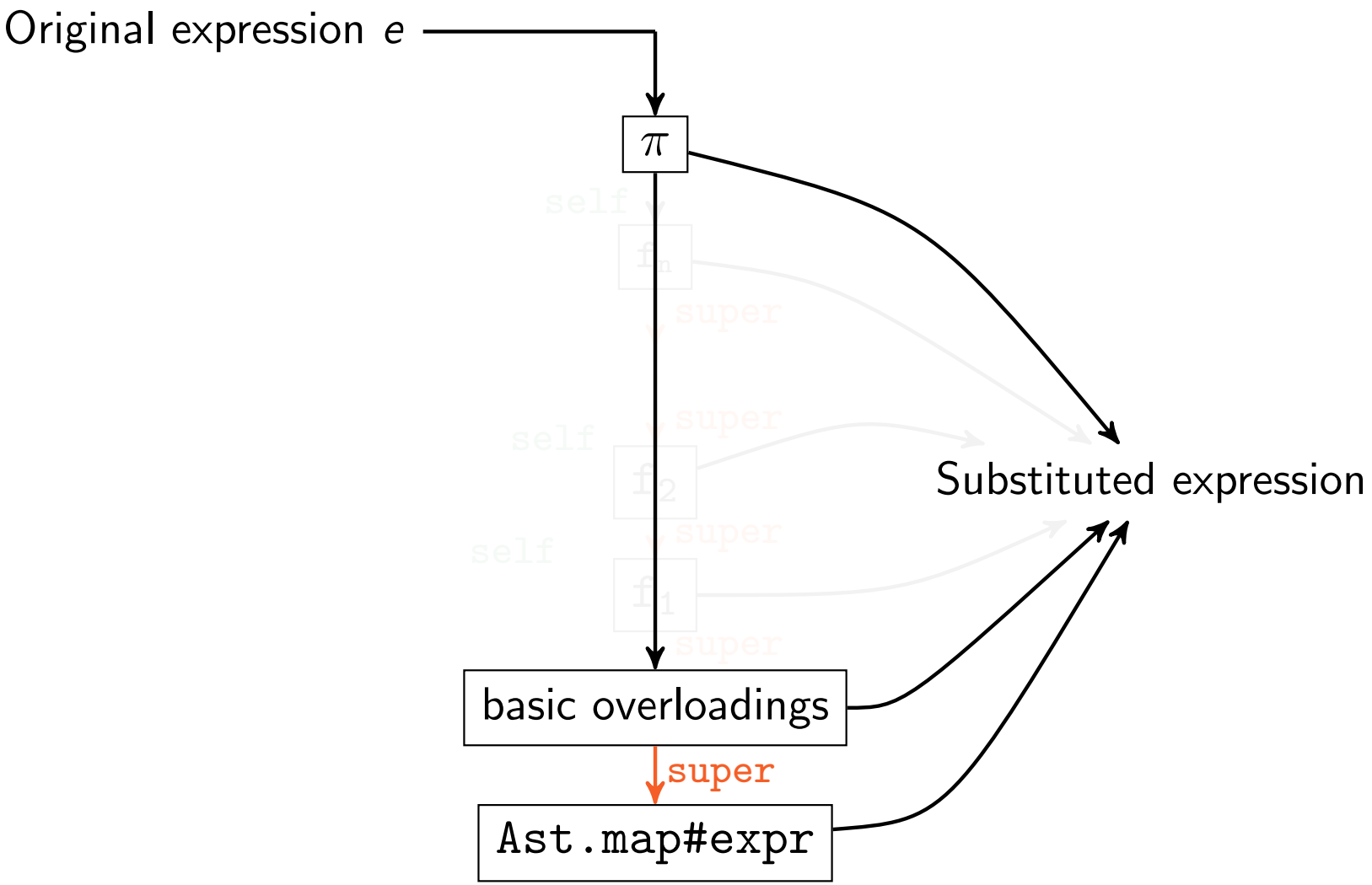

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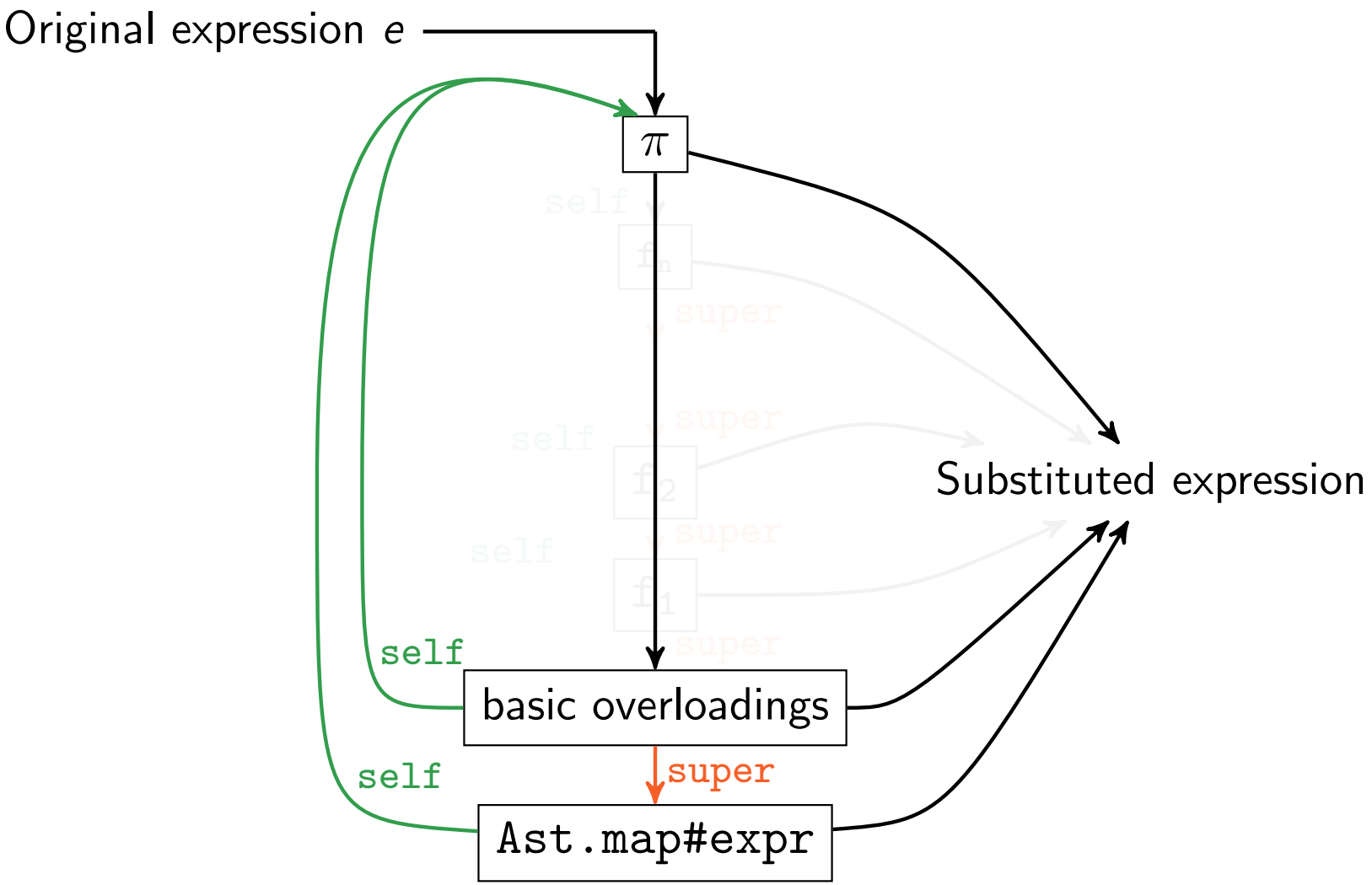

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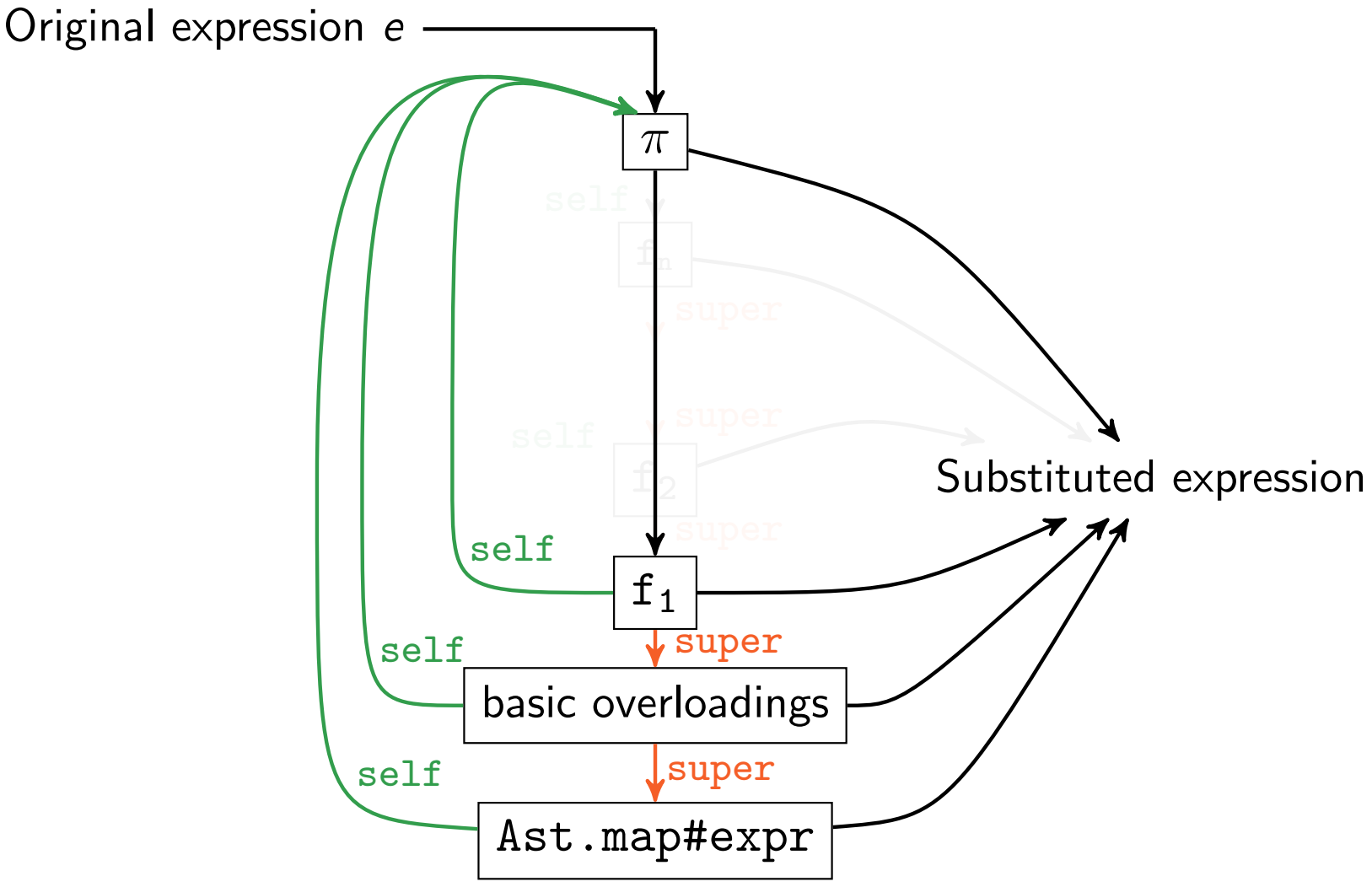

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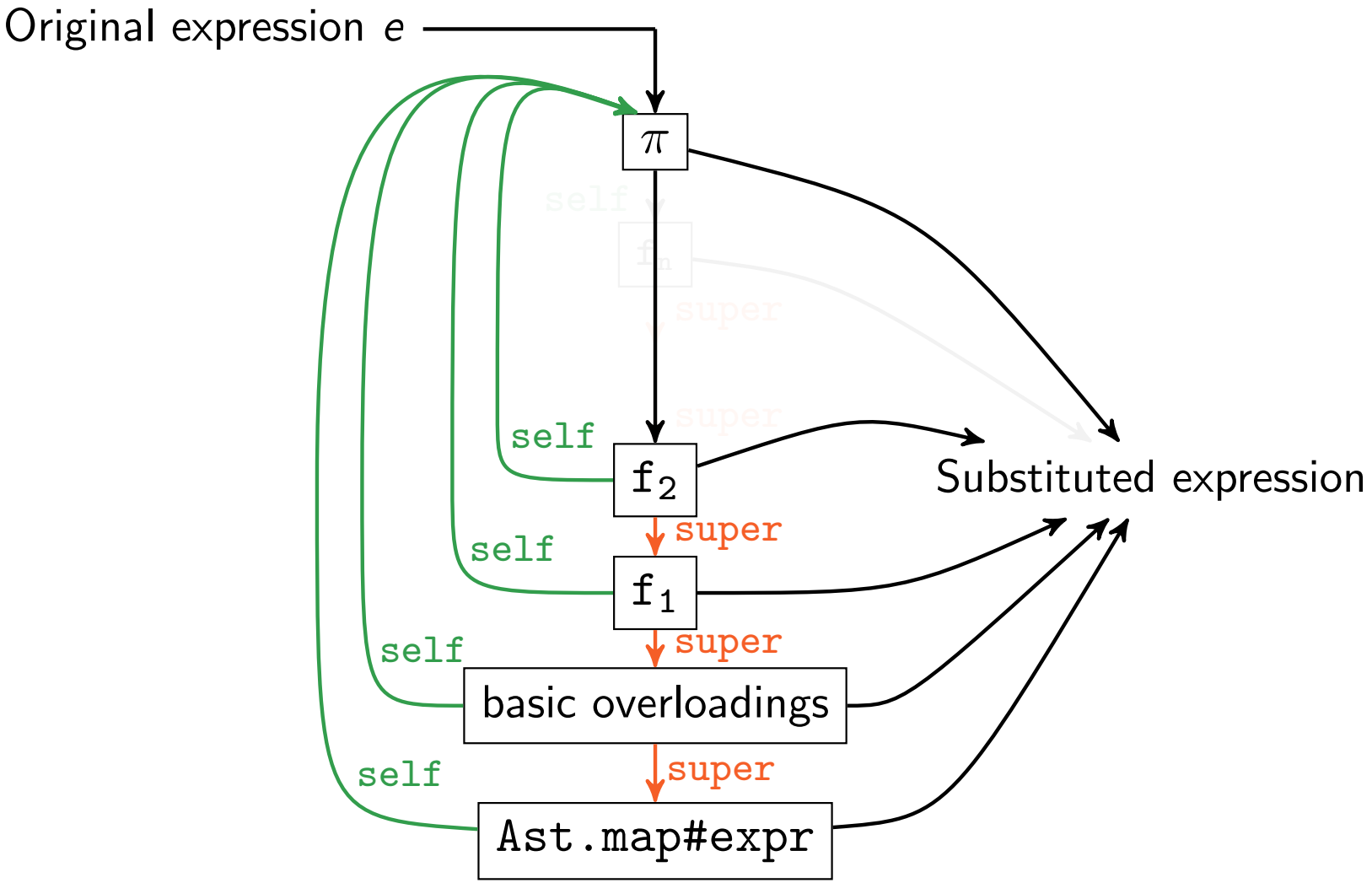

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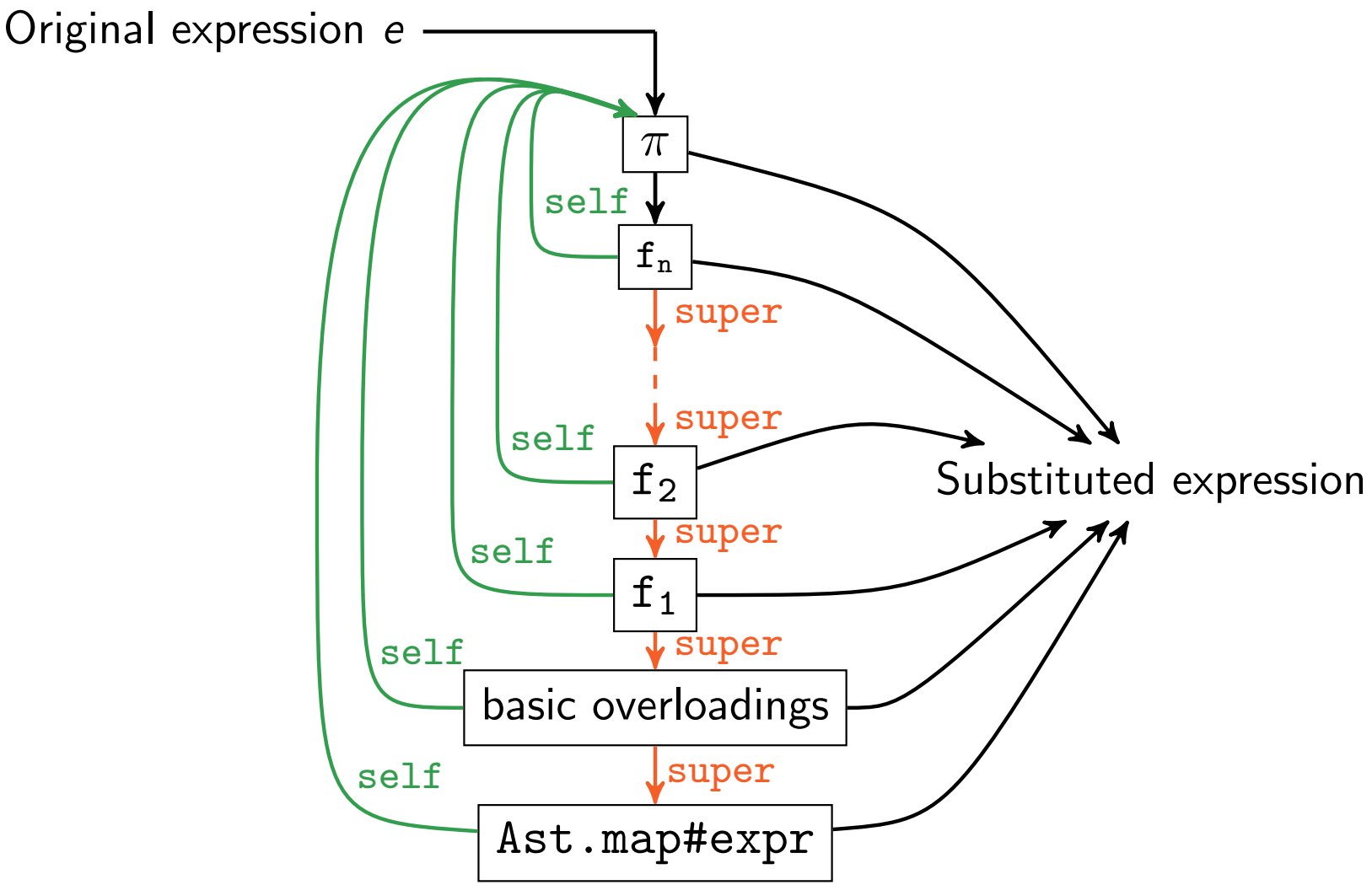

Thank you for your attention.