Let's Make Refactoring Tools User-extensible!

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RELEASE

Refactoring

Change how a program works without changing what it does

Why refactor?

Extension and reuse

```
loop_a() ->
    receive
      stop -> ok;
      {msg, _Msg, 0} -> loop_a();
      {msg, Msg, N} ->
        io:format("ping!~n"),
        timer:sleep(500),
        b ! {msg, Msg, N - 1},
        loop_a()
     end.
```

Let’s turn this into a function

Why refactor?

Extension and reuse

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loop_a() ->
    receive
      stop -> ok;
      {msg, _Msg, 0} -> loop_a();
      {msg, Msg, N} ->
        io:format("ping!~n"),
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     end.
```

```
loop_a() ->
    receive
      stop -> ok;
      {msg, _Msg, 0} -> loop_a();
      {msg, Msg, N} ->
        body(Msg,N),
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     end.

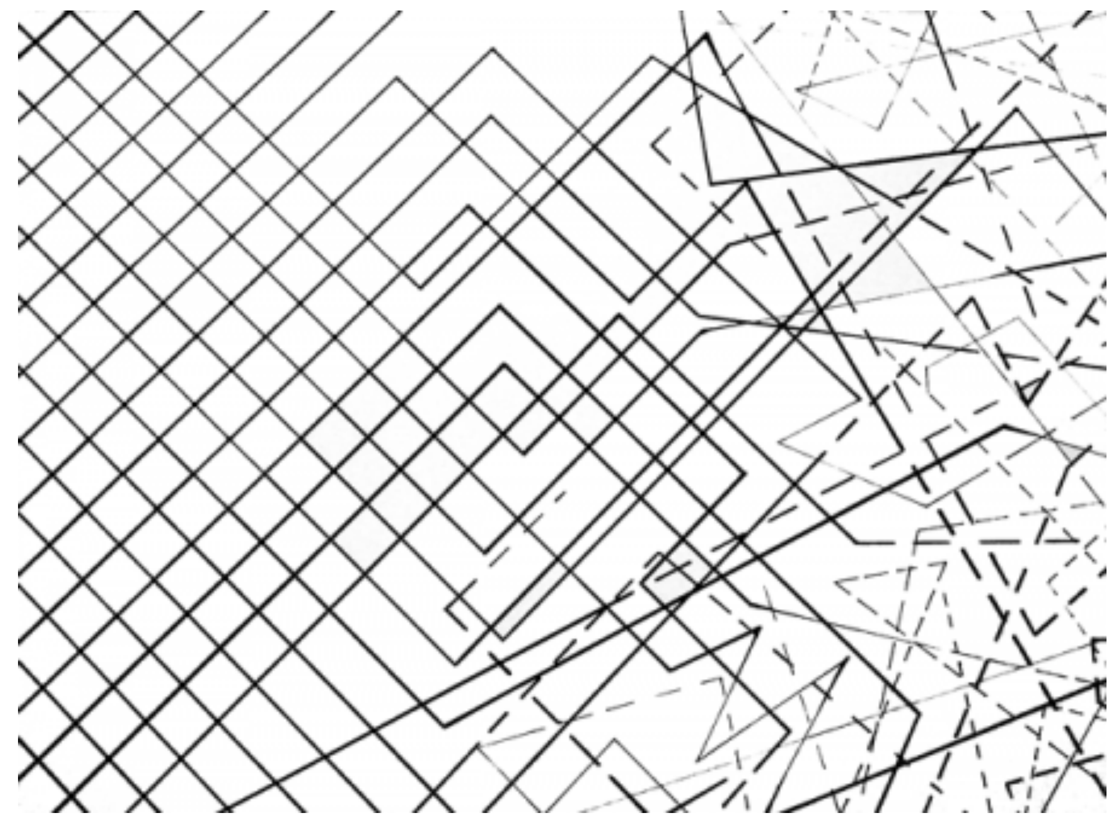
body(Msg,N) ->
      io:format("ping!~n"),
      timer:sleep(500),
      b ! {msg, Msg, N - 1}.
```

Why refactor?

Counteract decay ... comprehension

"Clones considered harmful": detect and eliminate duplicate code.

Improve the module structure: remove loops, for example.



How to refactor?

By hand … using an editor.

- Flexible … but error-prone.
- Infeasible in the large.

Tool supported.

- Handle atoms, names, side-effects, …
- Scalable to large-code bases.
- Integrated with tests, macros, ...

Wrangler

Clone detection and removal

Module structure improvement

Basic refactorings: structural, macro, process and test-framework related

Wrangler in a nutshell

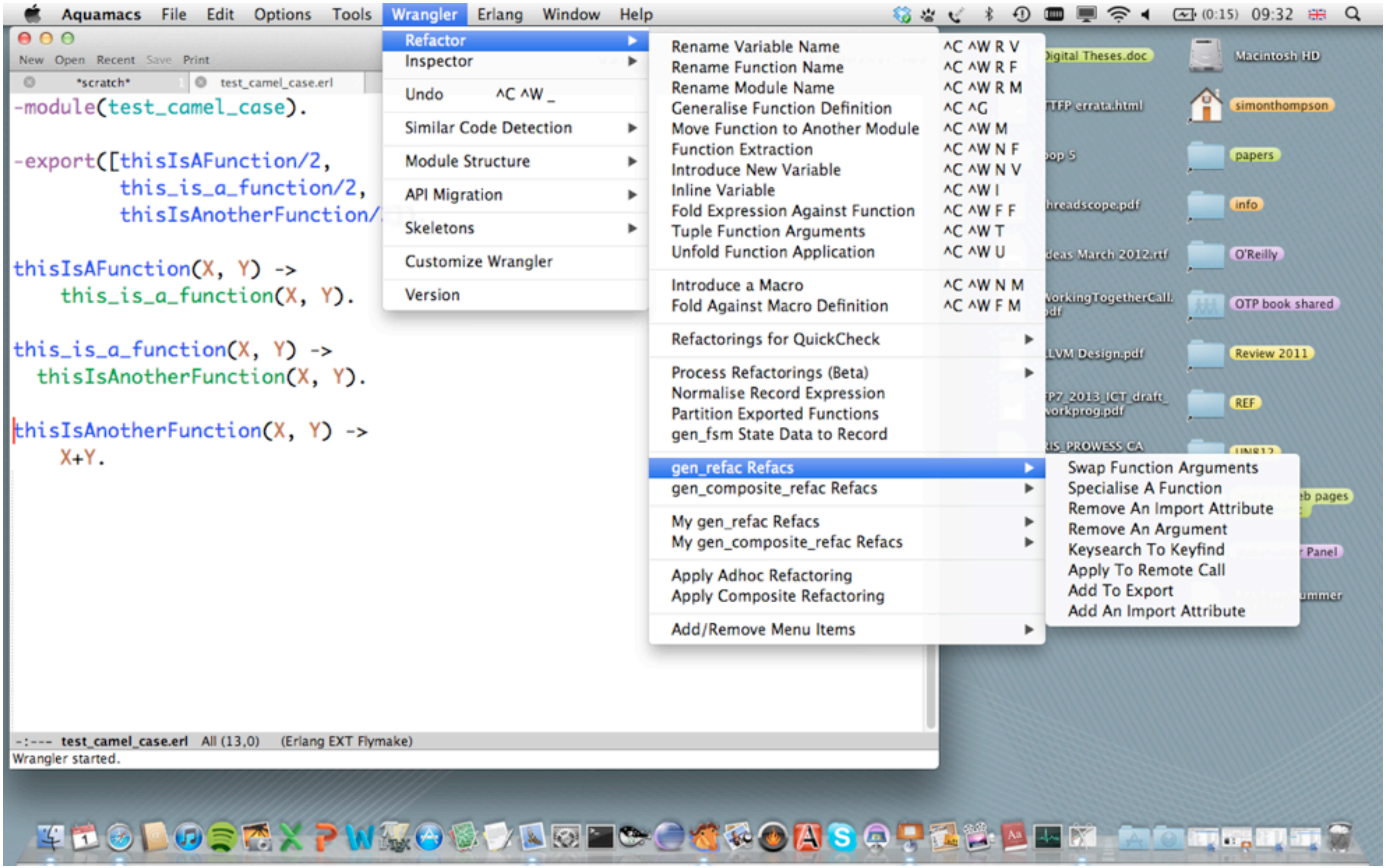
Automate the simple things, and …
… provide decision support tools otherwise.

Embed in common IDEs: emacs, eclipse, …

Handle full language, multiple modules, tests, ...

Faithful to layout and comments.

Build in Erlang and apply the tool to itself.


Aquamacs File Edit Options Tools Wrangler Erlang Window Help
09:32
New Open Recent Save Print
scratch
test_camel_case.erl
-module(test_camel_case).
-export([thisIsAFunction/2,
this_is_a_function/2,
thisIsAnotherFunction/
thisIsAFunction(X, Y) ->
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this_is_a_function(X, Y) ->
thisIsAnotherFunction(X, Y).
thisIsAnotherFunction(X, Y) ->
X+Y.
-:--- test_camel_case.erl All (13,0) (Erlang EXT Flymake)
Wrangler started.
Refactor
Inspector
Undo ^C ^W _
Similar Code Detection
Module Structure
API Migration
Skeletons
Customize Wrangler
Version
Rename Variable Name ^C ^W R V
Rename Function Name ^C ^W R F
Rename Module Name ^C ^W R M
Generalise Function Definition ^C ^G
Move Function to Another Module ^C ^W M
Function Extraction ^C ^W N F
Introduce New Variable ^C ^W N V
Inline Variable ^C ^W I
Fold Expression Against Function ^C ^W F F
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Process Refactorings (Beta)
Normalise Record Expression
Partition Exported Functions
gen_fsm State Data to Record
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My gen_refac Refacs
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Apply Adhoc Refactoring
Apply Composite Refactoring
Add/Remove Menu Items
Swap Function Arguments
Specialise A Function
Remove An Import Attribute
Remove An Argument
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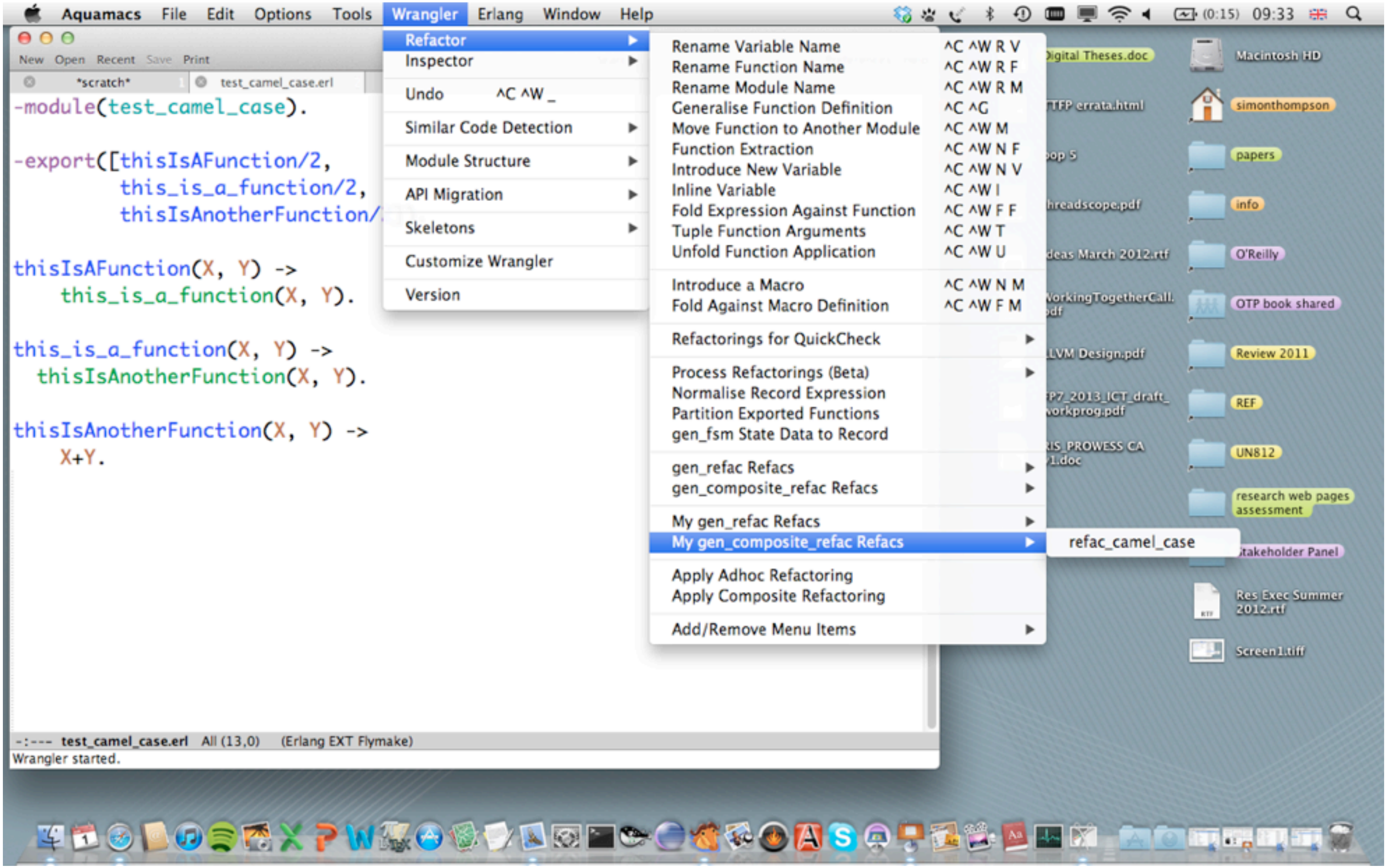
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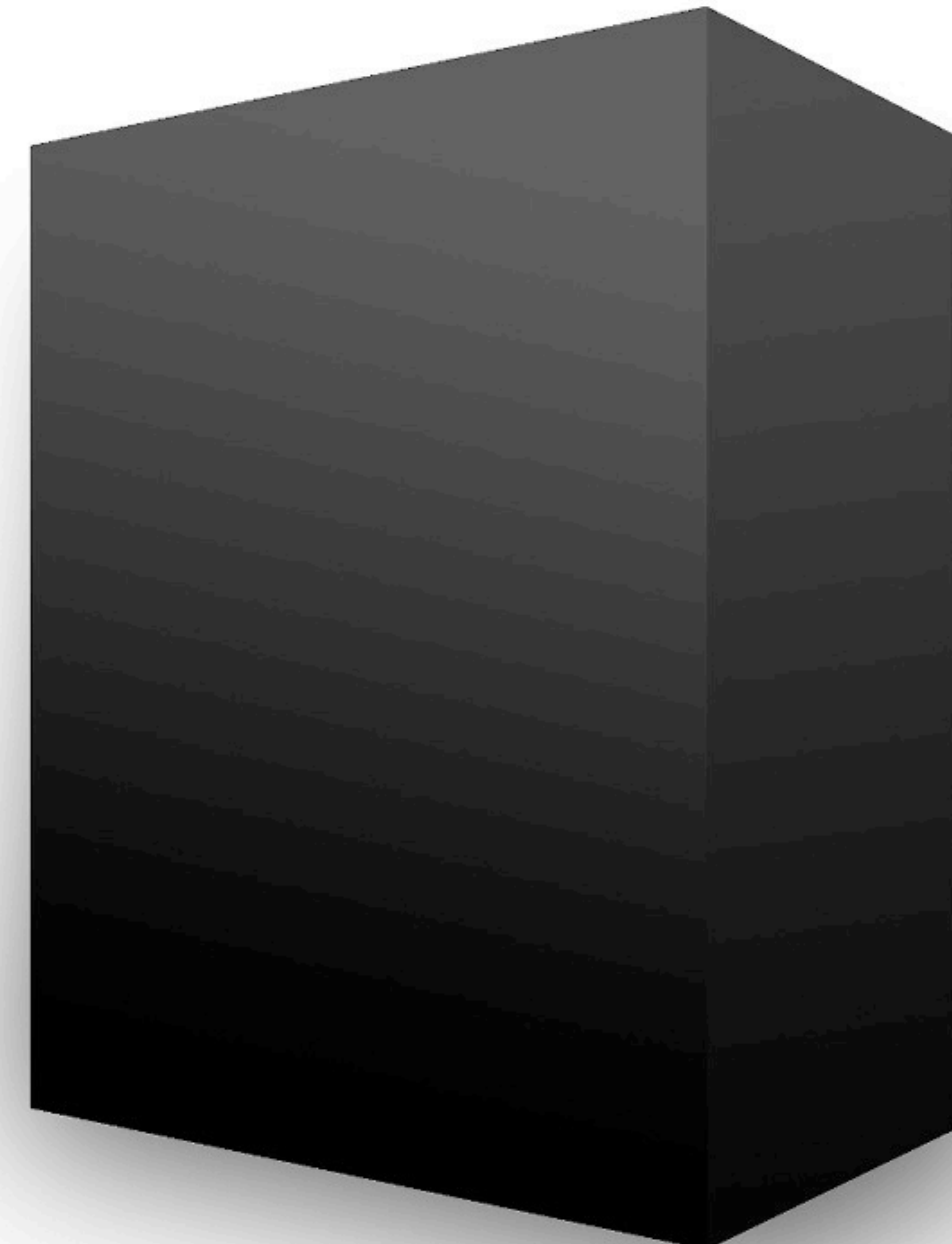

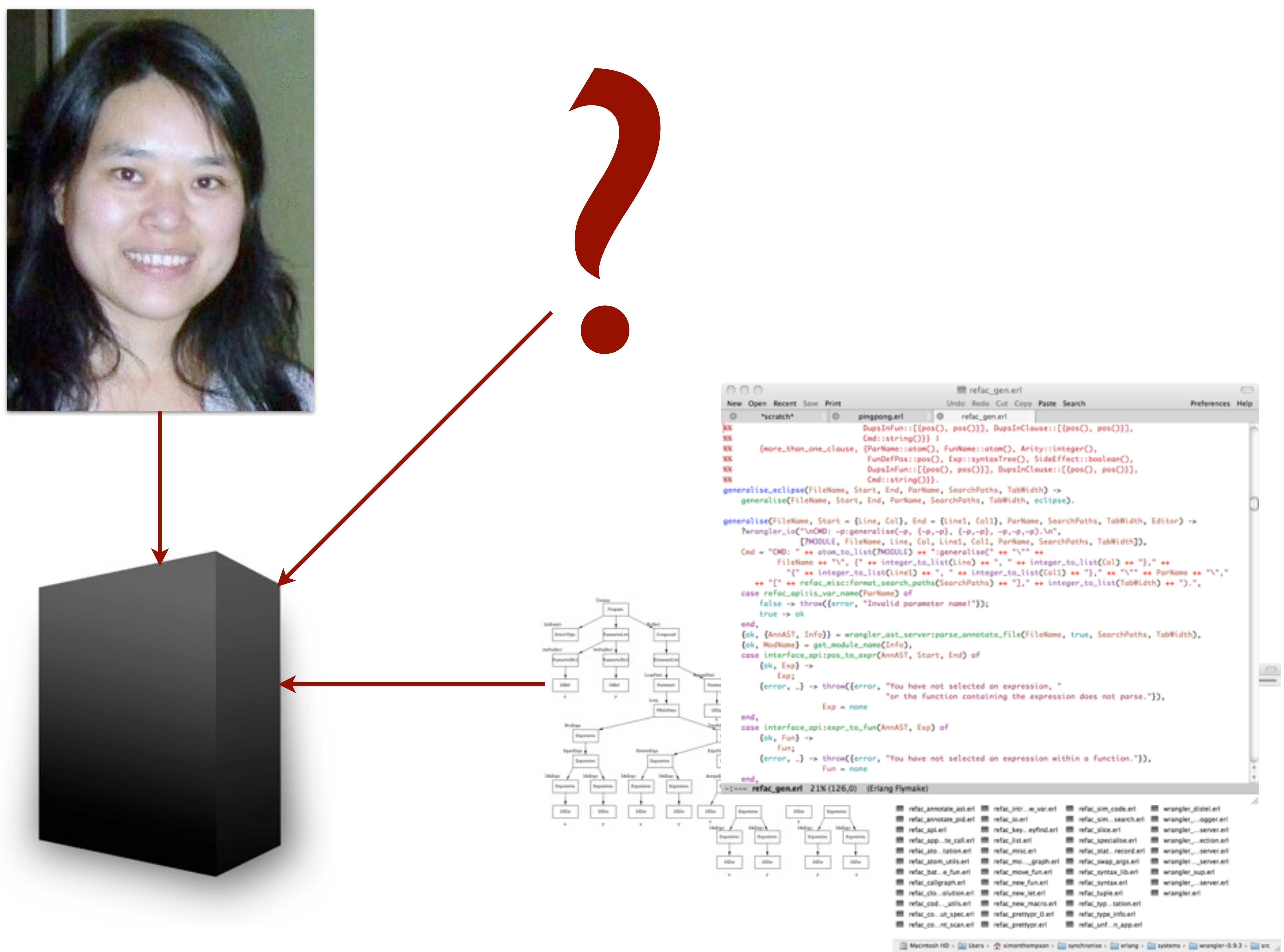

refac_gen.erl
New Open Recent Save Print
Undo Redo Cut Copy Paste Search
Preferences Help
scratch
pingpong.erl
refac_gen.erl

Two extensions

API	DSL
Describe entirely new ‘atomic’ refactorings from scratch.	A language to script composite refactorings on top of simpler ones.
e.g. swap args, delete argument.	e.g. remove clone, migrate API.

API

API design criteria

We assume you can program Erlang …

… but don't want to learn the internal syntax or details of our representation and libraries.

We aim for simplicity and clarity …

… rather than complete coverage.

Integration

Describe refactorings by a `behaviour` …

… that's Erlang-speak for a set of callbacks.

Integration with emacs for execution …

… which gives preview, undo, interactive behaviour etc. "for free".

Generalisation

Describe expressions in Erlang ...

```
loop_a() ->
     receive
       stop -> ok;
       {msg, _Msg, 0} -> loop_a();
       {msg, Msg, N} ->
        body(Msg,N),
        loop_a()
     end.

body(Msg,N) ->
        io:format("ping!~n"),
        timer:sleep(500),
        b ! {msg, Msg, N - 1}.
```

```
loop_a() ->
     receive
       stop -> ok;
       {msg, _Msg, 0} -> loop_a();
       {msg, Msg, N} ->
        body(Msg,N,"ping!~n"),
        loop_a()
     end.

body(Msg,N,Str) ->
        io:format(Str),
        timer:sleep(500),
        b ! {msg, Msg, N - 1}.
```

Generalisation

... how expressions are transformed ...

```
loop_a() ->
    receive
      stop -> ok;
      {msg, _Msg, 0} -> loop_a();
      {msg, Msg, N} ->
       body(Msg,N),
       loop_a()
    end.

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    end.

body(Msg,N,Str) ->
      io:format(Str),
      timer:sleep(500),
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```

Generalisation

... and its context and scope.

```
loop_a() ->
     receive
       stop -> ok;
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loop_a() ->
     receive
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       {msg, Msg, N} ->
        body(Msg,N,"ping!~n");
        loop_a()
      end.

body(Msg,N,Str) ->
       io:format(Str),
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```

Generalisation

Pre-conditions for refactorings

```
loop_a() ->
    receive
      stop -> ok;
      {msg, _Msg, 0} -> loop_a();
      {msg, Msg, N} ->
       body(Msg,N),
       loop_a()
     end.

body(Msg,N) ->
       io:format("ping!~n"),
       timer:sleep(500),
       b ! {msg, Msg, N - 1}.
```

Can't generalise over an expression that contains free variables ...

... or use the same name as an existing variable for the new variable.

Wrangler API

Context available for pre-conditions

Traversals describe how rules are applied

Rules describe transformations

Templates describe expressions

Templates

Templates are enclosed in the `?T` macro call.

Meta-variables in templates are Erlang variables ending in `@`, e.g. `F@`, `Arg@@`, `Guards@@@`.

```
?T("M:F@(1,2)")

?T("spawn(Args@@)")

?T("spawn(Arg1@,
     Arg2@,Args@@)")
```

`F@` matches a single element.

`Args@@` matches a sequence of elements of some kind.

Apply function `f`: `f(1,a,3)`

```
fun test_swap_args:f/3(1,a,3).

fun f/3(1,a,3).

test_swap_args:f(1,a,3).

apply(test_swap_args, f, [1,a,3]).

spawn(test_swap_args, f, [1,a,3]).

As = [1,a,3], apply(test_swap_args, f, As).

apply(fun test_swap_args:f/3, [1,2,3]).
```

Different concrete syntax for application.

Replace with single

`?FUN_APPLY(M,F,A)`

Rules

```
?RULE(Template, NewCode, Cond)
```

The old code, the new code and the pre-condition.

```
rule({M,F,A}, N) ->
 ?RULE(?T("F@(Args@@)"),
       begin
         NewArgs@@=delete(N, Args@@),
         ?TO_AST("F@(NewArgs@@)")
       end,
       refac_api:fun_define_info(F@) == {M,F,A}).

delete(N, List) ->  … delete Nth elem of List …
```

Information in the AAST

Wrangler uses the `syntax_tools` AST, augmented with information about the program semantics.

API functions provide access to this.

Variables bound, free and visible at a node.

Location information.

All bindings (if a vbl).

Where defined (if a fn).

Atom usage info: name, function, module etc.

Process info …

Collecting information

```
?COLLECT(Template, Collector, Cond)
```

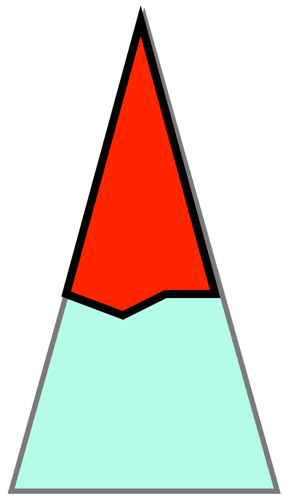
- The template to match.
- The information to extract ("collect").
- Condition on when to collect the information.

```
?COLLECT(?T("Body@@, V@=Expr@, V@"),
        {_File@, refac_api:start_end_loc(_This@)},
        refac_api:type(V@) == variable).
```

`_File@` current file `_This@` subtree matching `?T(...)`

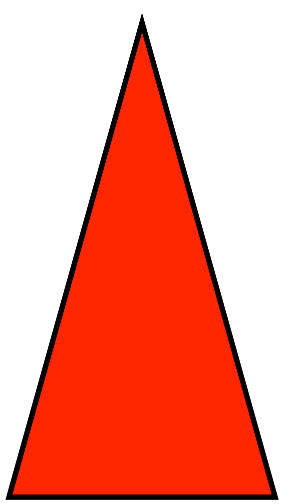
Traversals

```
?STOP_TD_TU(Collectors, Scope)
```



- Traverse top-down
- … apply all of the `Collectors` to succeed …
- … only visit sub-nodes if no collector has fired.
- `TU` = “Type unifying”.

```
?FULL_TD_TP(Rules, Scope)
```



- Traverse top-down
- At each node, apply first of `Rules` to succeed …
- `TP` = “Type preserving”.

DSL

How We Refactor, and How We Know It

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Abstract

Much of what we know about how programmers refactor in the wild is based on studies that examine just a few software projects. Researchers have rarely taken the time to replicate these studies in other contexts or to examine the assumptions on which they are based. To help put refactoring research on a sound scientific basis, we draw conclusions using four data sets spanning more than 13 000 developers, 240 000 tool-assisted refactorings, 2500 developer hours, and 3400 version control commits. Using these data, we cast doubt on several previously stated assumptions about how programmers refactor, while validating others. For example, we find that programmers frequently do not *indicate refactoring activity in commit logs, which contradicts assumptions made by several previous researchers. In contrast, we were able to confirm the assumption that programmers do frequently intersperse refactoring with other program changes. By confirming assumptions and replicating studies made by other researchers, we can have greater confidence that those researchers' conclusions are generalizable.*

a single research method: Weißgerber and Diehl's study of 3 open source projects [18]. Their research method was to

Up to 90% of refactorings done by hand

took place, non-refactoring code changes also took place. What we can learn from this depends on the relative frequency of high-level and mid-to-low-level refactorings. If

Some 40% of refactorings performed using tools are done in batches.

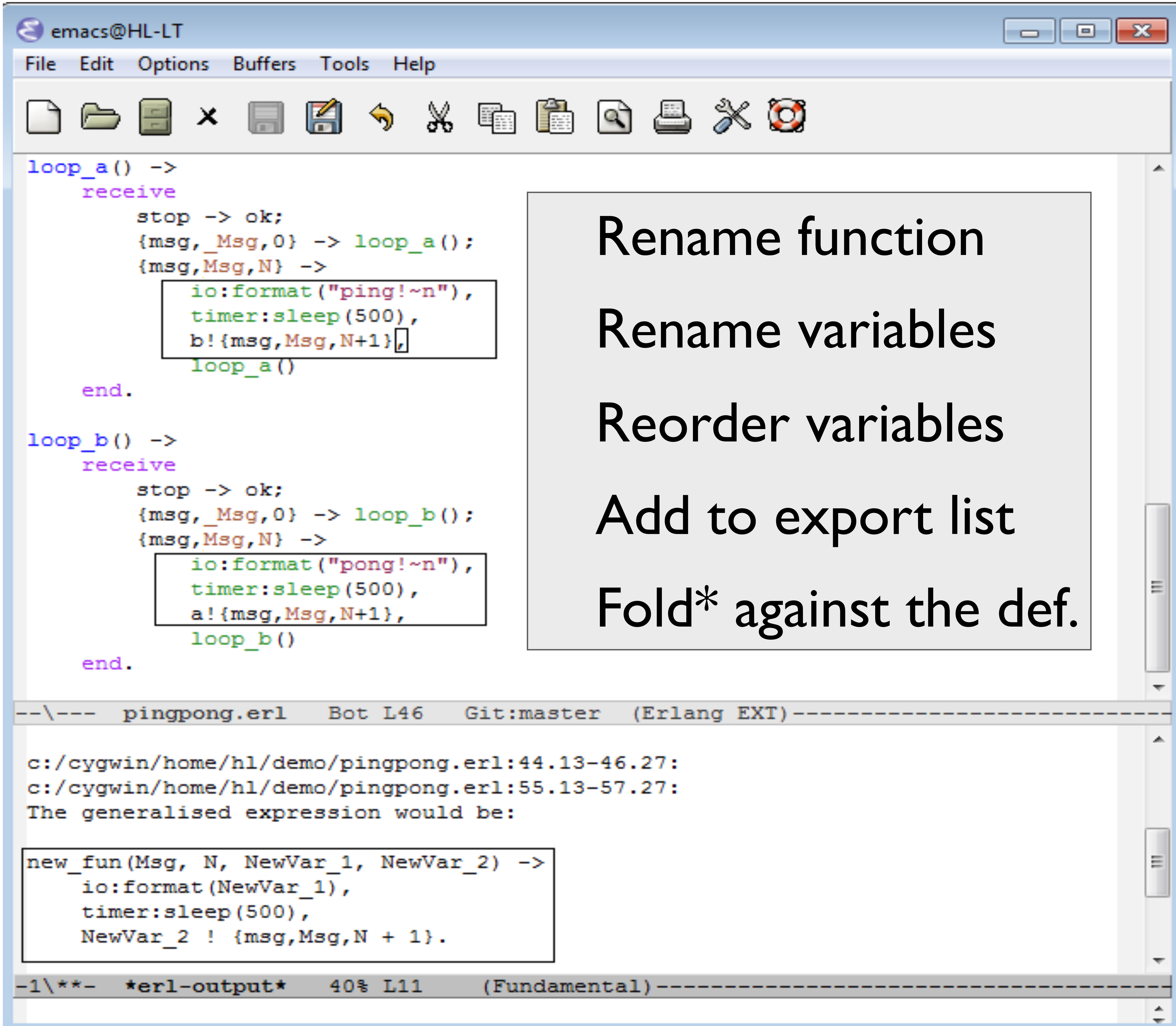
not have explored. In this paper we use both of these methods to confirm — and cast doubt on — several conclusions that have been published in the refactoring literature.

ICSE 2009

Composite refactorings

A sequence of simpler refactorings which together achieve a complex effect.

Example: transform all `camelCase` identifiers within a project into `camel_case`.


emacs@HL-LT
File Edit Options Buffers Tools Help
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receive
stop -> ok;
{msg,_Msg,0} -> loop_a();
{msg,Msg,N} ->
io:format("ping!~n"),
timer:sleep(500),
b!{msg,Msg,N+1},
loop_a()
end.
loop_b() ->
receive
stop -> ok;
{msg,_Msg,0} -> loop_b();
{msg,Msg,N} ->
io:format("pong!~n"),
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end.
Rename function
Rename variables
Reorder variables
Add to export list
Fold* against the def.
--\--- pingpong.erl Bot L46 Git:master (Erlang EXT)
c:/cygwin/home/hl/demo/pingpong.erl:44.13-46.27:
c:/cygwin/home/hl/demo/pingpong.erl:55.13-57.27:
The generalised expression would be:
new_fun(Msg, N, NewVar_1, NewVar_2) ->
io:format(NewVar_1),
timer:sleep(500),
NewVar_2 ! {msg,Msg,N + 1}.
-1**- *erl-output* 40% L11 (Fundamental)

Not just a script ...

Tracking changing names and positions.

Generating refactoring commands.

Dealing with failure.

User control of execution.

… we're dealing with the *pragmatics* of composition, rather than just the theory.

Generators

Refactoring functions modified to take *descriptions* of arguments, rather than concrete arguments.

```
rename_fun(Module,{Fun,Arity},NewName) -> ok | error

rename_fun(fun(Module) -> boolean(),
           fun({Fun,Arity}) -> boolean(),
           fun(Module,{Fun,Arity}) -> atom(),
           boolean())
          ->
          { [ {refactoring, rename_fun, Args} ], fun}
```

Generation: camel case

```
?refac_(CmdName, Args, Scope)
```

Args: modules, camelCase functions, new names.

```
?refac_(rename_fun,
          [{file, fun(_File)-> true end},
           fun({F, _A}) ->
                    camelCase_to_camel_case(F) /= F
           end,
           {generator, fun({_File, F,_A}) ->
                           camelCase_to_camel_case(F)
                       end}],
        SearchPaths).
```

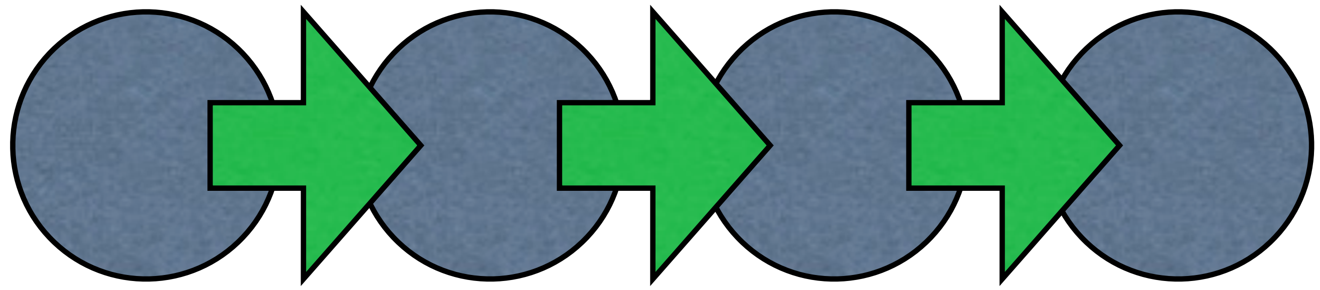
Automation

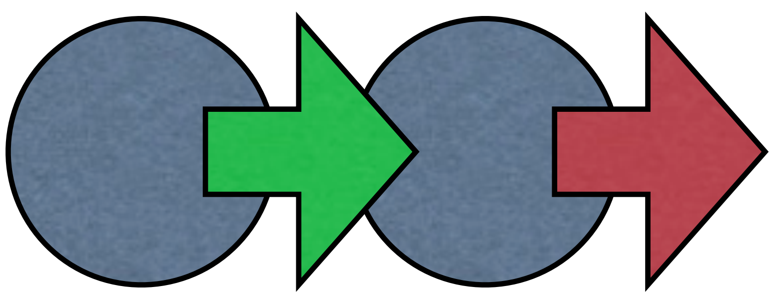
Don't have to describe each command explicitly: allow *conditions* and *generators*.

Allow lazy generation … return a refactoring command together with a *continuation*.

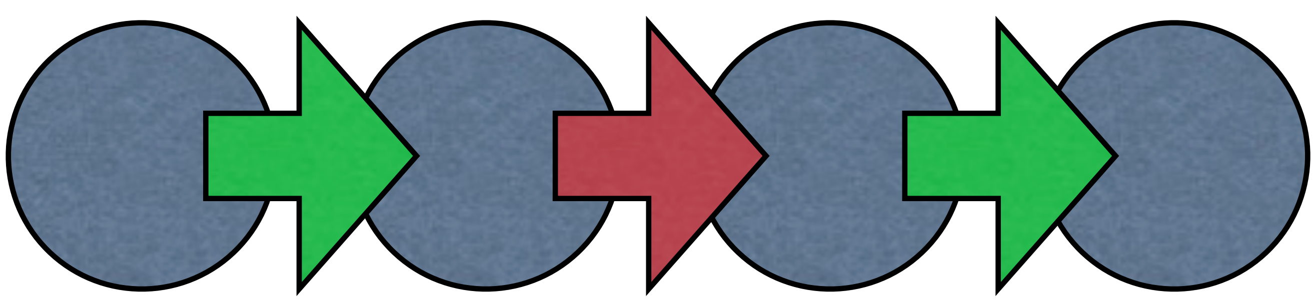
Track names, so that `?current(foo)` gives the ‘current’ name of an entity `foo` at any point in the refactoring.

Handling failure



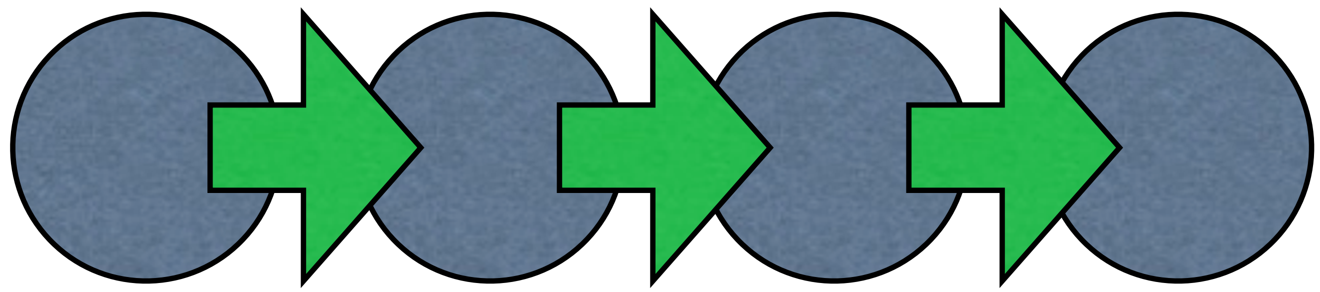


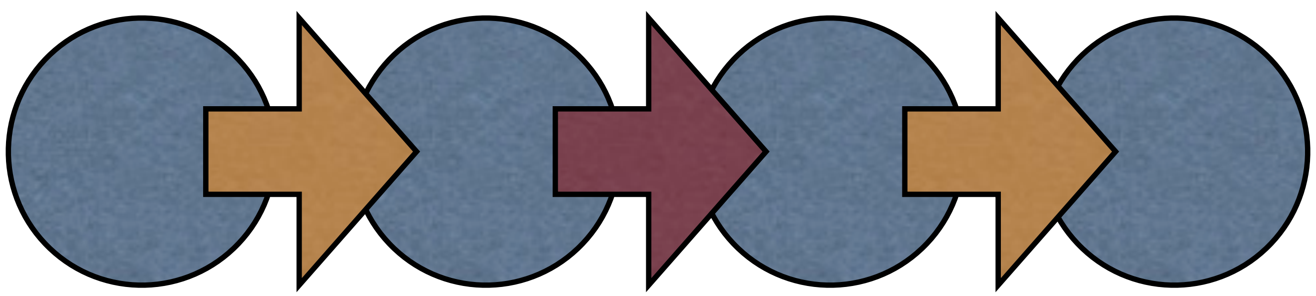
Transaction: if one part fails, *abandon* the whole.



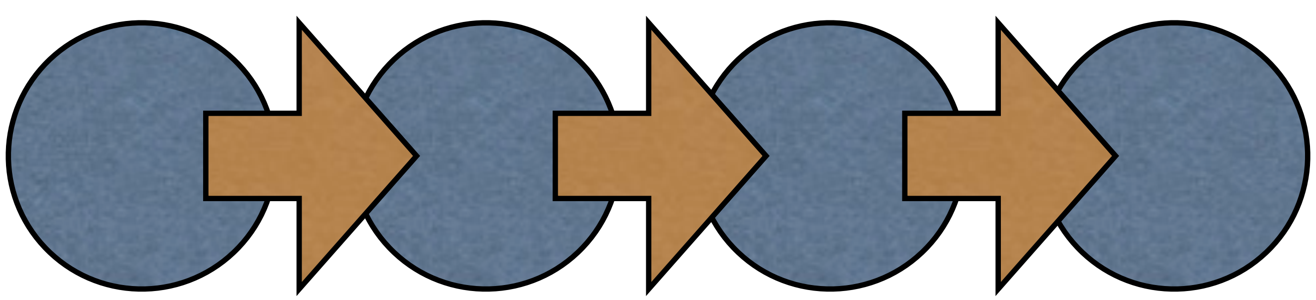
Otherwise: *continue* even when failure.

Handling interaction



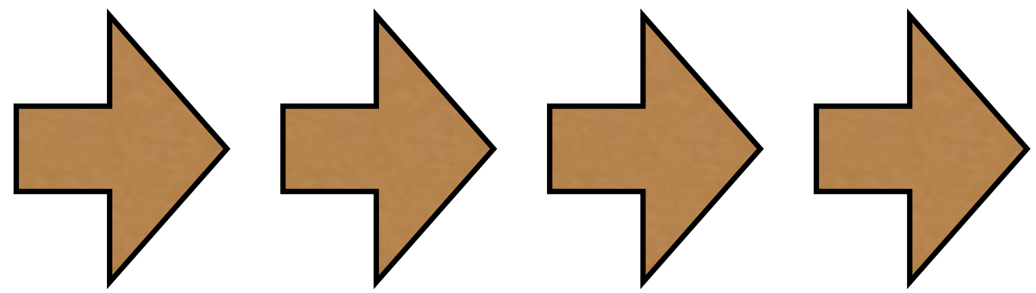


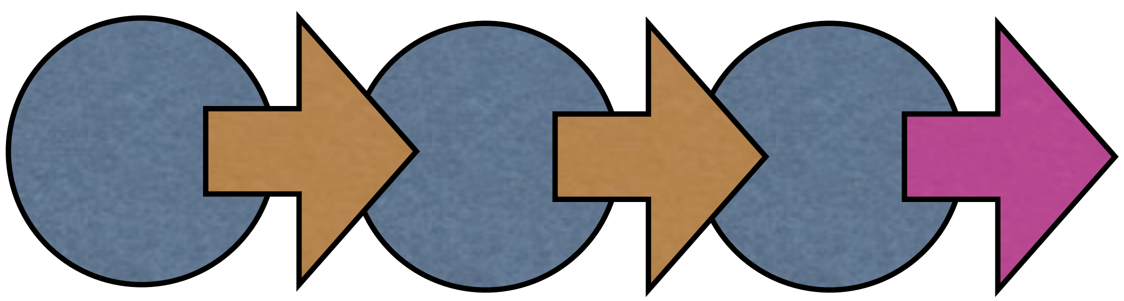
Interactive: *choose* the cases to perform.



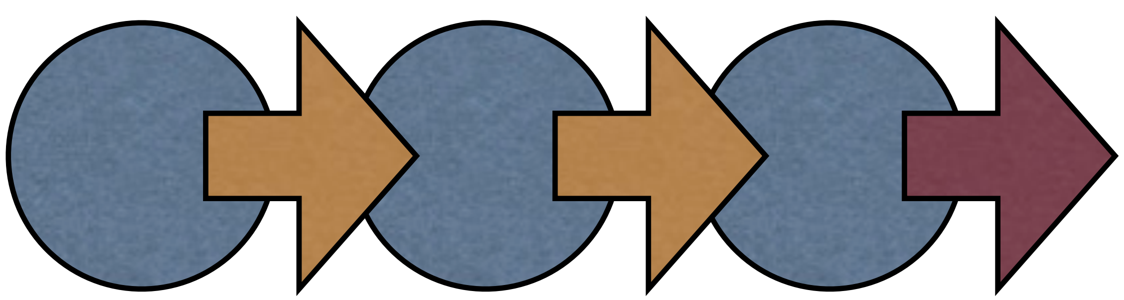
Non-interactive: *perform all cases.*

Handling repetition





Condition: *repeat* while a condition is true.



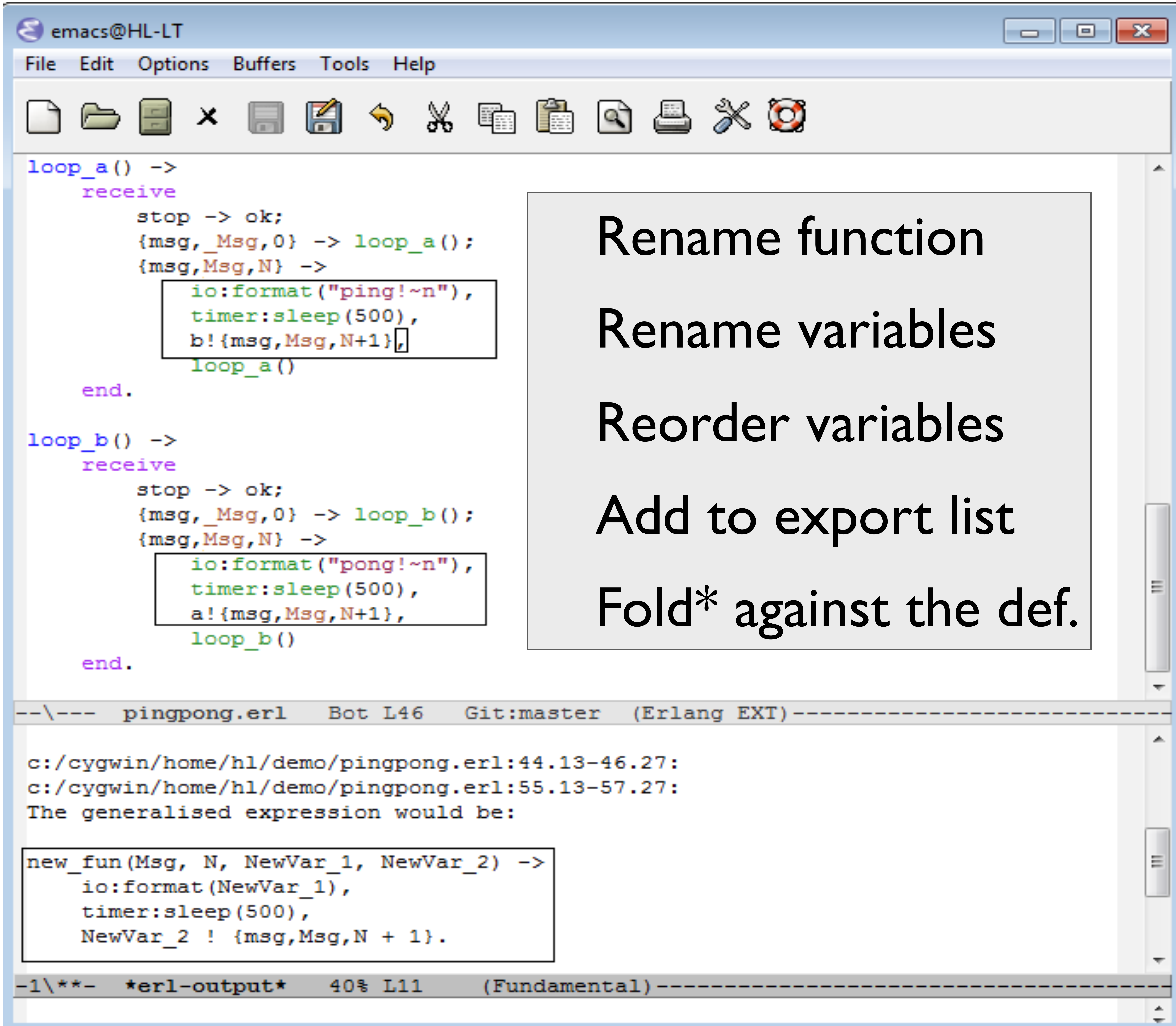
Interactively: *ask* whether to repeat.

Building a DSL

Domain specific language to support options of atomicity, interactivity etc.

Embed in Erlang to leverage the language e.g. to define conditions and generators.

Use Erlang to represent the language, and *macros* to support.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timer:sleep(500),
b!{msg,Msg,N+1},
loop_a()
end.
loop_b() ->
receive
stop -> ok;
{msg,_Msg,0} -> loop_b();
{msg,Msg,N} ->
io:format("pong!~n"),
timer:sleep(500),
a!{msg,Msg,N+1},
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end.
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-1**- *erl-output* 40% L11 (Fundamental)

Clone removal: top level

Atomic as a whole … non-atomic components OK.

Not just an API: `?atomic` etc. modify interpretation of what they enclose …

```
?atomic([?interactive( RENAME FUNCTION )
         ?refac_( RENAME ALL VARIABLES OF THE
                  FORM NewVar* )
         ?repeat_interactive( SWAP ARGUMENTS )
         ?if_then( EXPORT IF NOT ALREADY )
         ?non_atomic( FOLD INSTANCES OF THE CLONE )
        ]).
```

Erlang and DSL

```
?refac_(rename_var,
        [M,
         begin
           {_, F1, A1} = ?current(M,F,A),
           {F1, A1}
         end,
         fun(X) ->
             re:run(atom_to_list(X), "NewVar*")/=nomatch
         end,
         {user_input, fun({_, _, V}) ->
                           lists:flatten(io_lib:format
                                   "Rename variable ~p to: ", [V]))
                      end},
         SearchPaths])
```

Remove bug preconditions

Remove bug preconditions

Scenario: building Erlang models for C code.

For buggy code, want to avoid hitting the same bugs all the time

Add bug precondition macros …

… but want to remove in delivered code.

DSL: fuses 3 steps. *API*: first two. *Built in*: third.

Step 1: simple rules

```
replace_bug_cond_macro_rule() ->
    ?RULE(?T("Expr@"),
          ?TO_AST("false"),
          is_bug_cond_macro(Expr@)).

logic_rule_1() ->
    ?RULE(?T("not false"),?TO_AST("true"),true).
```

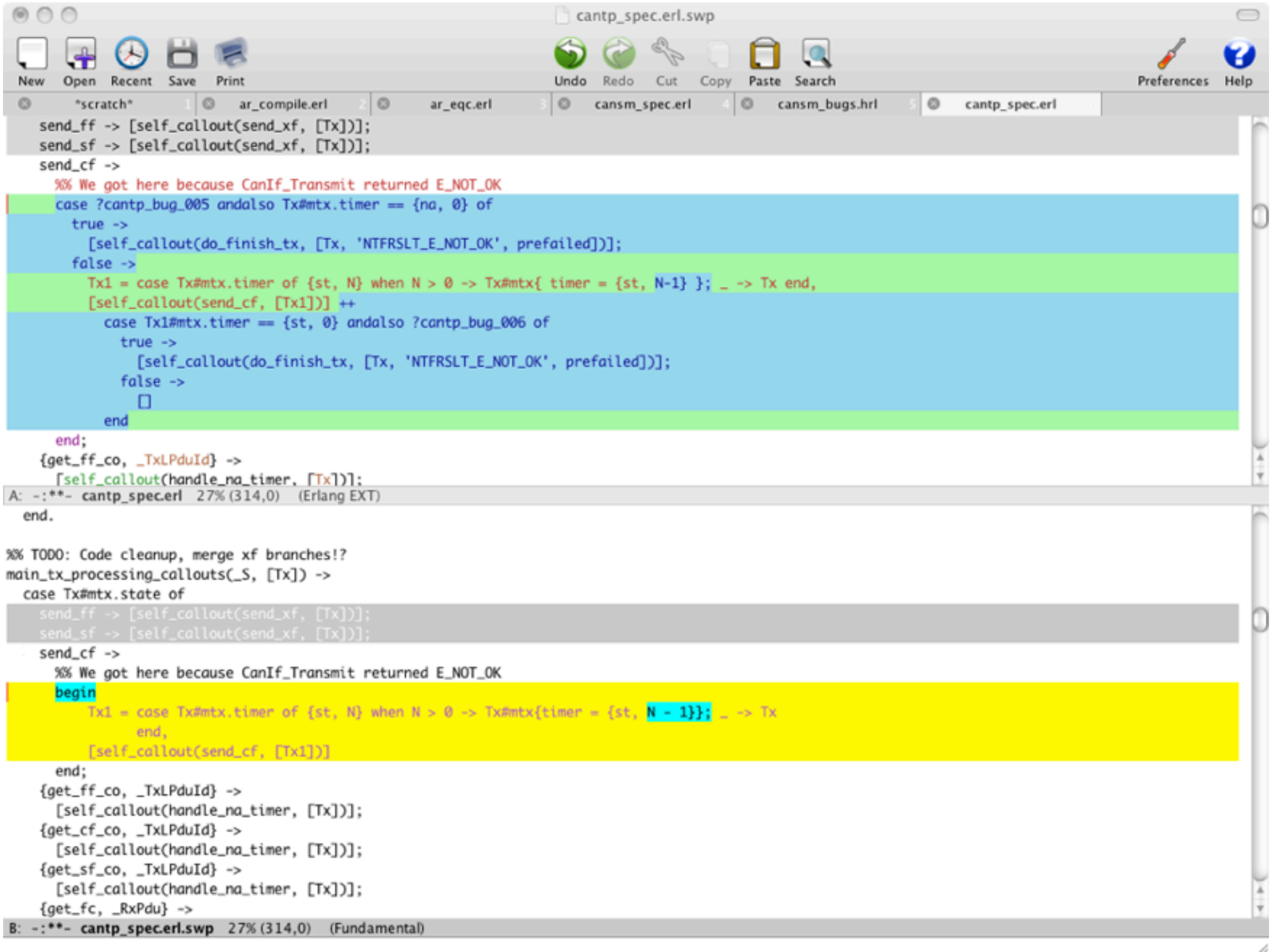
Step 2: tidy up

```
case false of
  true  -> com_cfg:initial_value(Sig);
  false -> get_shadow_value(Id, S)
end.
```

Simplifies to `get_shadow_value(Id, S)`.

Step 3: inline variables

```
route_data_next(S,_, [{{SrcKind,SrcId}, Dst, Val}], _) ->
    % clear gateway pending flag
    NewS = set_gateway_pending(S, SrcKind, SrcId, false),
    S2   = NewS,
    copy_to_destination(S2, Dst, Val).
```


cantp_spec.erl.swp
New
Open
Recent
Save
Print
Undo
Redo
Cut
Copy
Paste
Search
Preferences
Help
scratch
ar_compile.erl
ar_eqc.erl
cansm_spec.erl
cansm_bugs.hrl
cantp_spec.erl
send_ff -> [self_callout(send_xf, [Tx])];
send_sf -> [self_callout(send_xf, [Tx])];
send_cf ->
%% We got here because CanIf_Transmit returned E_NOT_OK
case ?cantp_bug_005 andalso Tx#mtx.timer == {na, 0} of
true ->
[self_callout(do_finish_tx, [Tx, 'NTFRSLT_E_NOT_OK', prefailed])];
false ->
Tx1 = case Tx#mtx.timer of {st, N} when N > 0 -> Tx#mtx{ timer = {st, N-1} }; _ -> Tx end,
[self_callout(send_cf, [Tx1])] ++
case Tx1#mtx.timer == {st, 0} andalso ?cantp_bug_006 of
true ->
[self_callout(do_finish_tx, [Tx, 'NTFRSLT_E_NOT_OK', prefailed])];
false ->
[]
end
end;
{get_ff_co, _TxLPduId} ->
[self_callout(handle_na_timer, [Tx])];
A: -:**- cantp_spec.erl 27% (314,0) (Erlang EXT)
end.
%% TODO: Code cleanup, merge xf branches!?
main_tx_processing_callouts(_S, [Tx]) ->
case Tx#mtx.state of
send_ff -> [self_callout(send_xf, [Tx])];
send_sf -> [self_callout(send_xf, [Tx])];
send_cf ->
%% We got here because CanIf_Transmit returned E_NOT_OK
begin
Tx1 = case Tx#mtx.timer of {st, N} when N > 0 -> Tx#mtx{timer = {st, N - 1}}; _ -> Tx
end,
[self_callout(send_cf, [Tx1])]
end;
{get_ff_co, _TxLPduId} ->
[self_callout(handle_na_timer, [Tx])];
{get_cf_co, _TxLPduId} ->
[self_callout(handle_na_timer, [Tx])];
{get_sf_co, _TxLPduId} ->
[self_callout(handle_na_timer, [Tx])];
{get_fc, _RxPdu} ->
B: -:**- cantp_spec.erl.swp 27% (314,0) (Fundamental)

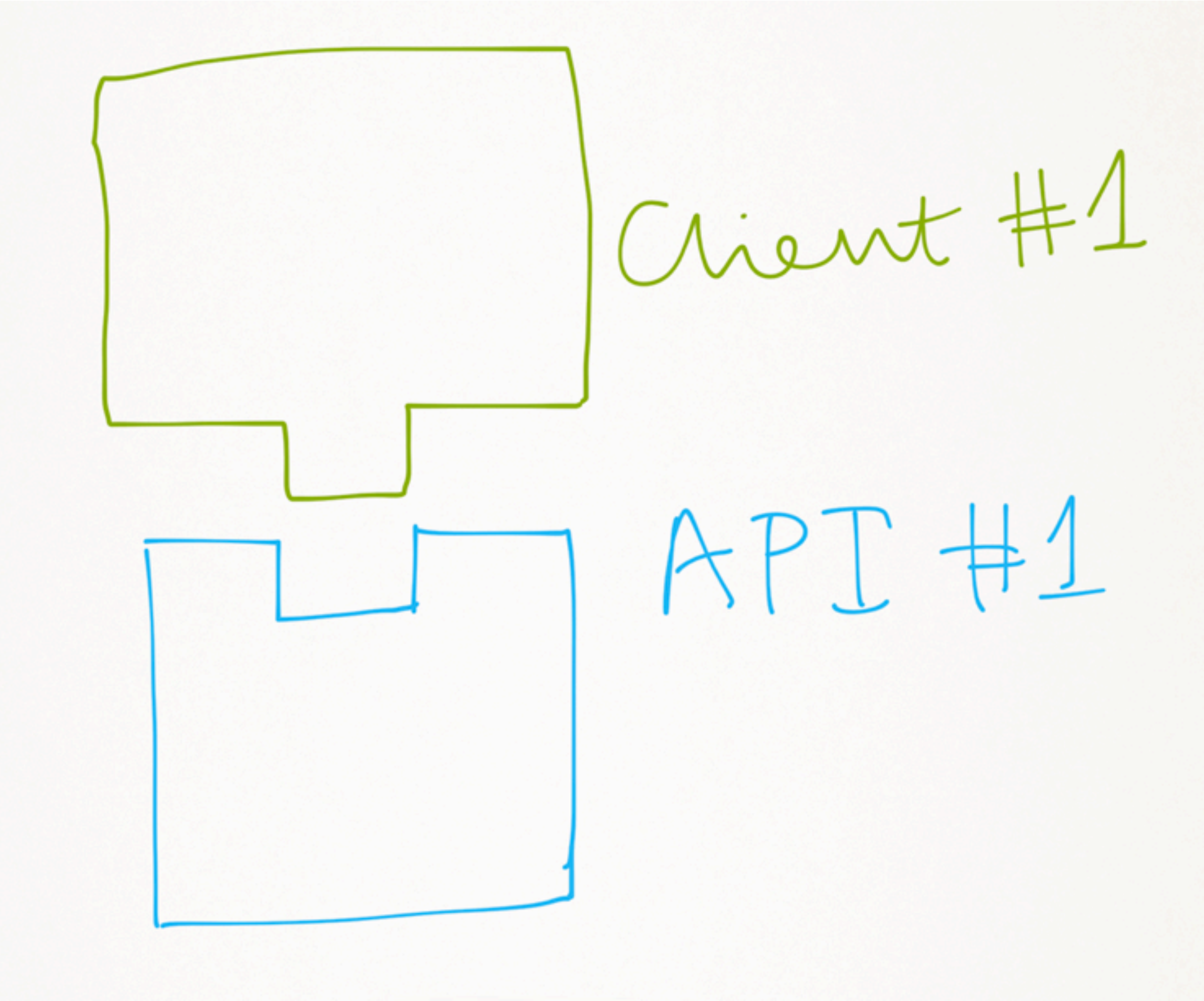
API Migration

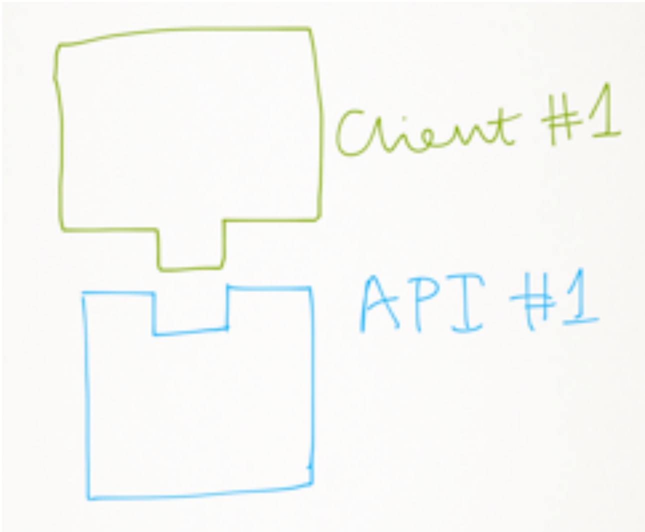
API migration

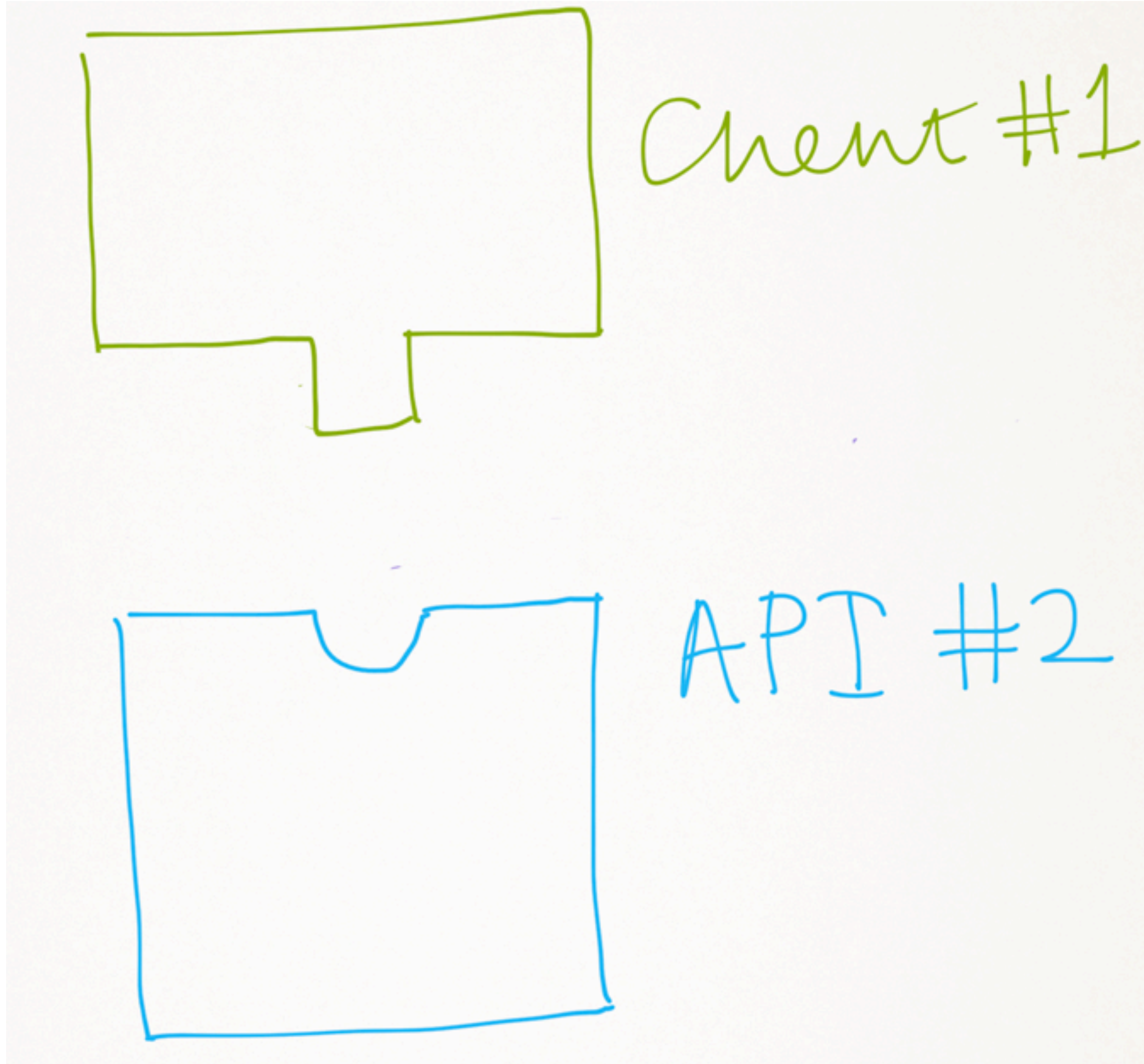
Scenario: system upgrade accompanied with a change in API.

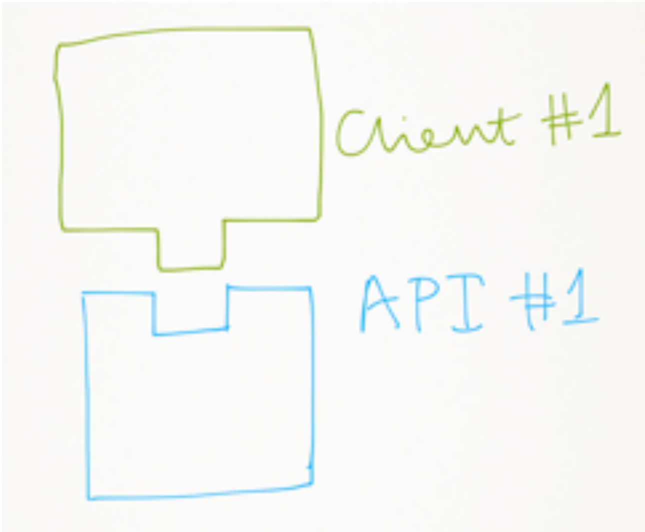
Example from Erlang standard distribution: the regular expression library from `regexp` to `re`.

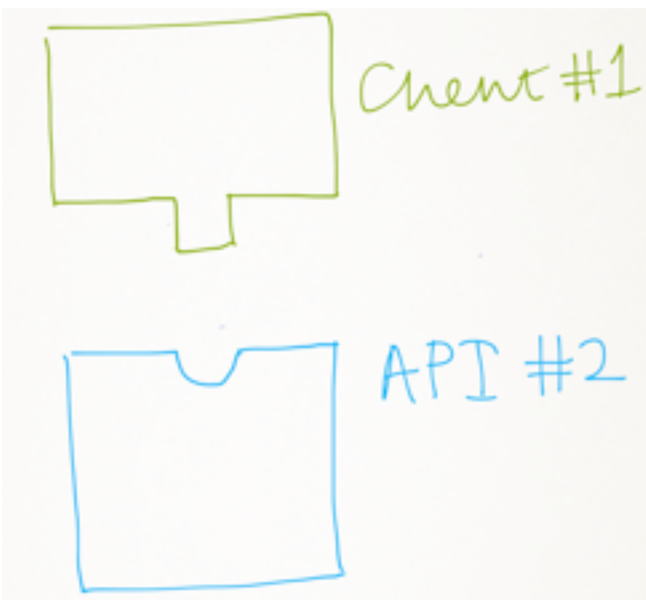
How to refactor client code to accommodate this?

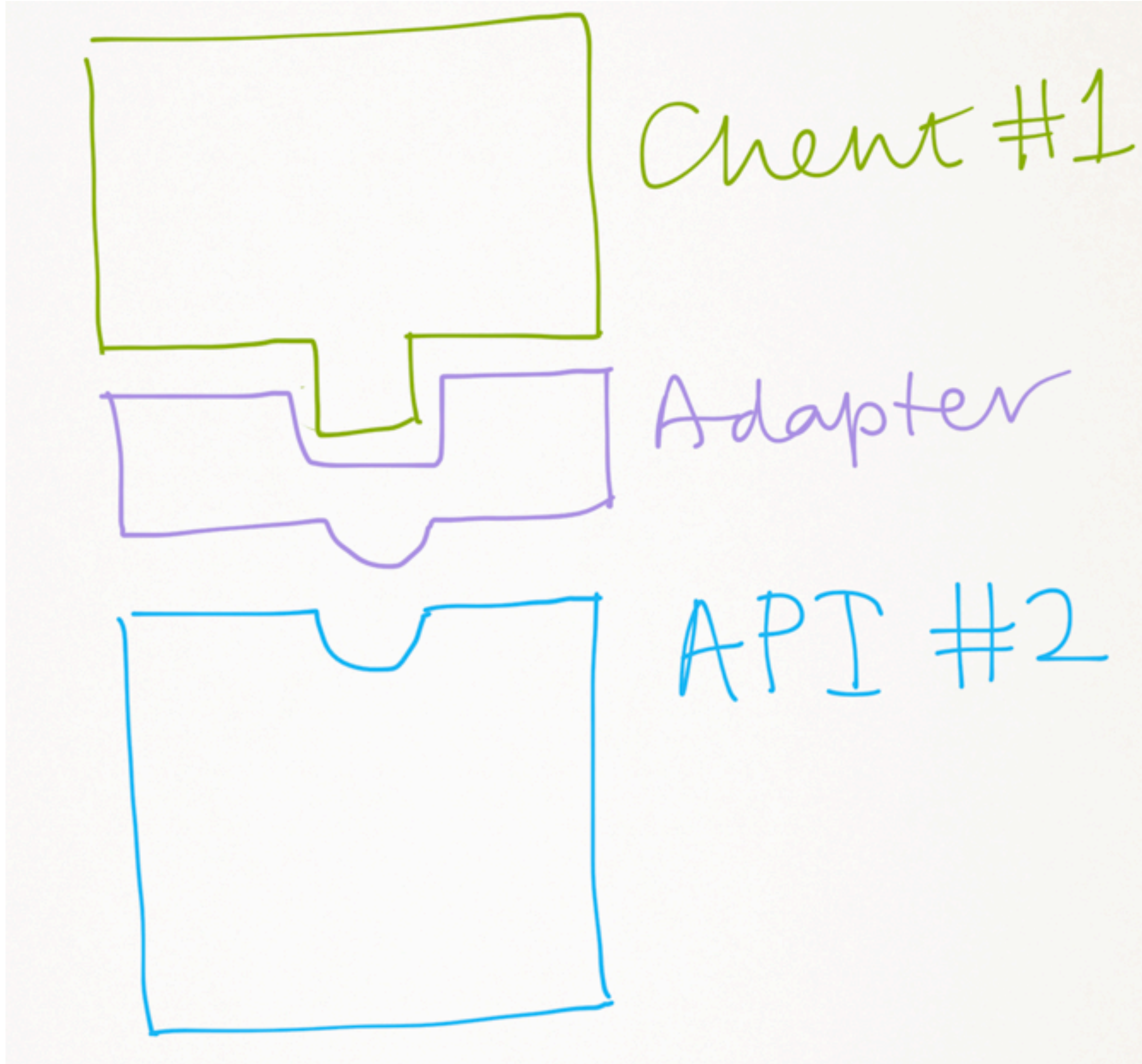

Client #1
API #1

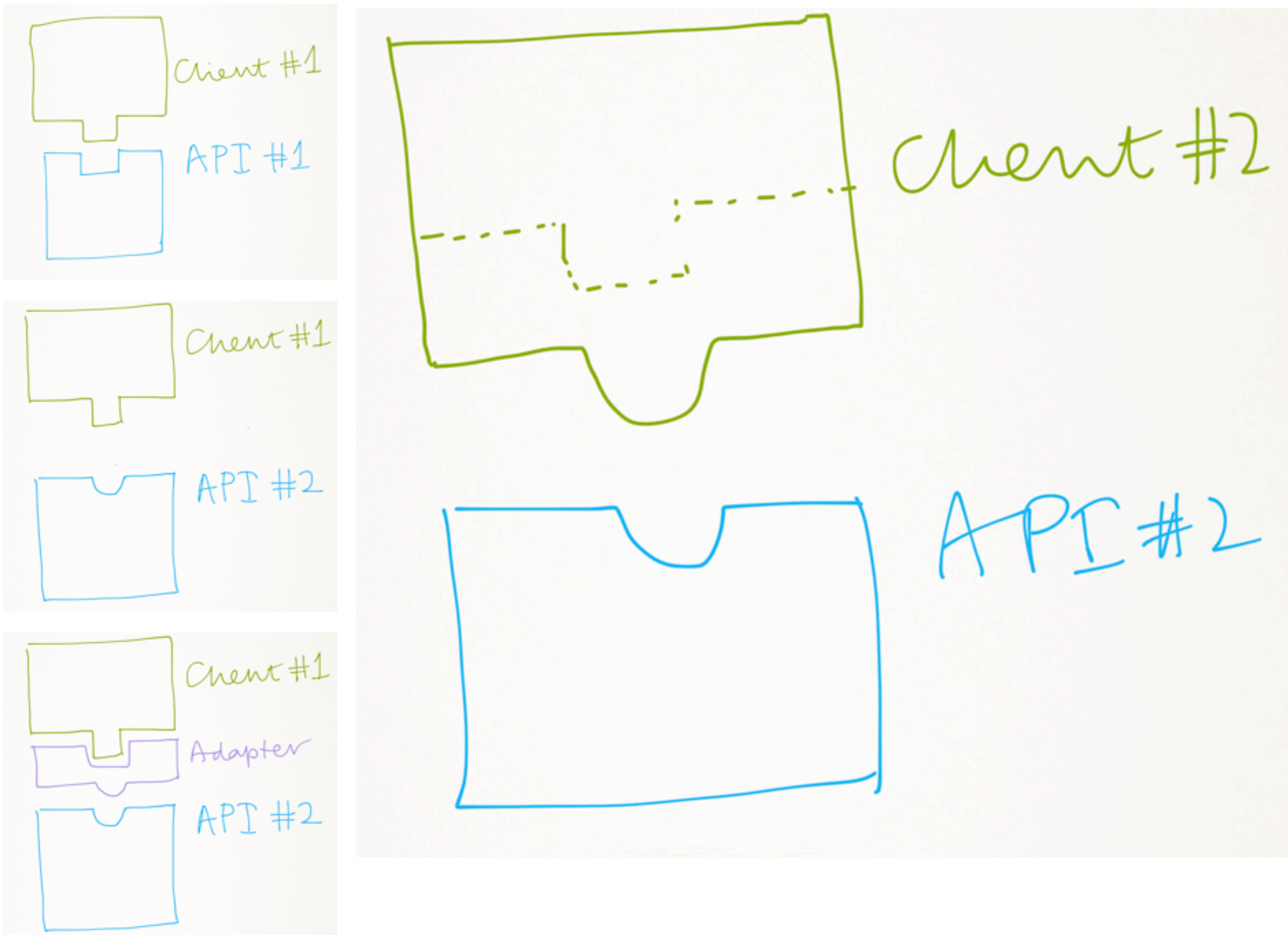

Client #1
API #1


Client #1
API #2


Client #1
API #1


Client #1
API #2


Client #1
Adapter
API #2



Client #1
API #1
Client #1
API #2
Client #1
Adapter
API #2
Client #2
API #2

Adapter regexp to re

```
match(String, RegExp) ->
    try re:run(String, RegExp, [global]) of
        {match, Match} ->
           {Start0, Len} = lists:last(
                                 lists:ukeysort(
                                   2, lists:append(Match))),
           Start = Start0+1,
           {match, Start, Len};
       nomatch -> nomatch
    catch
       error:_->
           {error, Error}=re:compile(RegExp),
           {error, Error}
    end.
```

Generate rules

From the adapter module we generate rules which “fold” the adapter into the client code, and build a refactoring to apply them automatically …

The transformation rules

A meta-rule with the template code as a `case` expression.

A rule with the template code as a match expression: `V@=regexp:match(S@,RE@)`

A rule with the template code an application of the old API function: `regexp:match(S@,RE@)`

Applying the rules

Step 1: apply the meta-rule.

Step 2: first apply *introduce new variable refactoring* for each application, then use the rule for: `V@=regexp:match(S@,RE@)`

Step 3: apply the third rule.

After each step cleanup to remove unused variables / expressions.

Client #1

```
secret_path(Path, [[NewDir] | Rest], Dir) ->
  case regexp:match(Path, NewDir) of
    {match, _Start, _Len} when Dir == to_be_found ->
      secret_path(Path, Rest, NewDir);
    {match, _Start, _Len} ->
          secret_path(Path, Rest, Dir);
    nomatch ->
      secret_path(Path, Rest, Dir)
  end.
```

Client #2

```
secret_path(Path, [[NewDir] | Rest], Dir) ->
  case re:run(Path, NewDir, [global]) of
    {match, _Match} when Dir == to_be_found ->
      secret_path(Path, Rest, NewDir);
    {match, _Match} ->
      secret_path(Path, Rest, Dir);
    nomatch ->
      secret_path(Path, Rest, Dir)
  end.
```

Client #1

```
document_name(Path) ->
  case regexp:match(Path,"[^/]*\$") of
    {match, Start, Len} ->
      string:substr(Path, Start, Len);
    nomatch -> "(none)"
  end.
```

Client #2

```
document_name(Path) ->
  case re:run(Path, "[^/]*\$", [global]) of
    {match, Match} ->
      {Start0, Len}=lists:last(lists:ukeysort(2,Match)),
      Start = Start0 + 1,
      string:substr(Path, Start, Len);
    nomatch -> "(none)"
  end.
```

Conclusions

Conclusions

Remove one of the barriers to adoption?

Two complementary features: API and DSL.

Go with the grain of the language.

More case studies … e.g. in RELEASE project.

Works for other languages and tools?

What next?

Refining the detailed design.

User contributions.

Application to other languages …

Questions?

www.cs.kent.ac.uk/projects/wrangler

RELEASE