HERE BE DRAGONS

charting parse transforms in Erlang

Our journey

What is a parse transform?

Erlang Manual:

> Programmers are strongly advised not to engage in parse transforms and no support is offered for problems encountered.

The Abstract Format

Our journey

What is a parse transform?

Program as data

Working with Abstract Format

Bring your sword to the dragon fight

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Parse transforms in the wild

Other monsters in the menagerie

Our journey

What is a parse transform?

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Parse transforms in the wild

Inline parse transform

Have the dragon eat it's own tail

What is a parse transform?

Source

↓

Compiler

↓

Executable

`module.erl`

↓

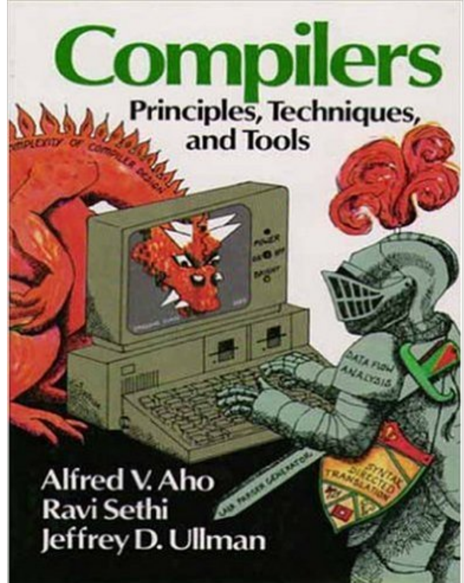
```
> erlc module.erl
```

↓

`module.beam`

Classic compilation steps

1. Expand macros
2. Lex
3. Parse
4. Abstract syntax tree
5. Optimize
6. Generate bytecode



Classic compilation steps

1. Expand macros
2. Lex
3. Parse
4. Abstract syntax tree
5. → Transformed syntax tree = `your_function(AST)` ←
6. Optimize
7. Generate bytecode

Identity transform

```
-module(my_transform).

-export([parse_transform/2]).

parse_transform(Forms, Options) ->
  Forms.
```

Invoke a parse transform

erlc

```
erlc my_transform.erl
erlc -pa . +"{parse_transform,my_transform}" test.erl
```

rebar.config

```
{erl_opts, [
            {parse_transform, my_transform}
           ]}.
```

module inline

```
-module(test).

-compile([{parse_transform, my_transform}]).

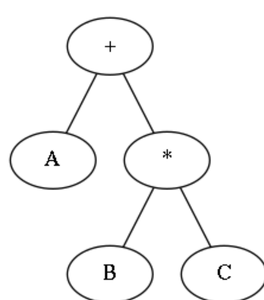
...
```

Abstract Format

Your program as data

Abstract Syntax Tree

A + B * C



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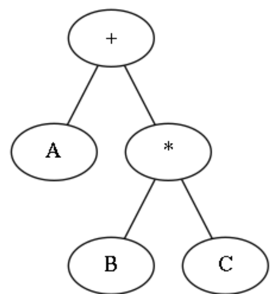

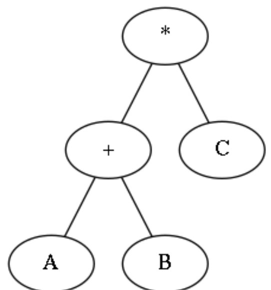

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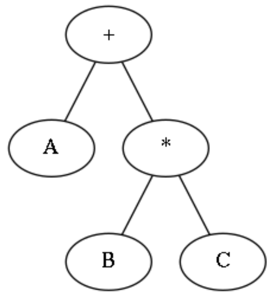
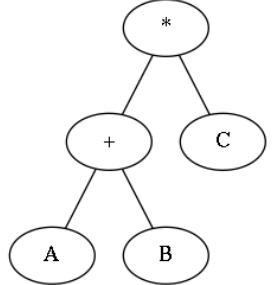



```
{'+',
  A,
  {'*', B, C}}
```

(A + B) * C




```
{'*',
  {'+', A, B},
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```erlang
-module(test).

-compile([{parse_transform, my_transform}]).

-export([hello/1]).

hello(Who) ->
    io:fwrite("hello ~p", [Who]).
```

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 {attribute,5,export,[{hello,1}]},
 {function,7,hello,1,
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                    [{var,7,'Who'}],
                    [],
                    [{call,8,
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```

Setting Sail

Transform some parse trees!

Hypothetical application

Whenever the ETS table `contentious_table` is accessed, fire off a message to a tracker process with the ETS method used: select / insert / update / delete.

The tracker process could then accumulate number of calls / time. You could begin to get an idea of what processes are using this table and how often.

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- Insert: `ets_collector ! {insert, self()}`

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Problem

- Find: `ets:insert(contentious_table, Objects)`
- Insert: `ets_collector ! {insert, self()}`
- Bonus: `ets_collector ! {insert, length(Objects), self()}`

What does that look like in AF???

```
1> {ok, Tokens, _} =
       erl_scan:string("ets:insert(contentious_table, Objects).").

2> {ok, Forms} = erl_parse:parse_exprs(Tokens).

3> Forms.
[{call,1,
       {remote,1,{atom,1,ets},{atom,1,insert}},
       [{atom,1,contentious_table},{var,1,'Objects'}]}]
```

Just make sure not to match on `Objects` since the variable name might be different.

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[{call,1,
       {remote,1,{atom,1,ets},{atom,1,insert}},
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```

OK, match on

```
{call, _,
 {remote, _, {atom, _, ets}, {atom, _, insert}},
 [{atom, _, contentious_table}, {var, _, 'Objects'}]}
```

... and insert ...

```
1> {ok, Tokens, _} =
       erl_scan:string("ets_collector ! {insert, self()}.").

2> {ok, Forms} = erl_parse:parse_exprs(Tokens).

3> Forms.
[{op,1,'!',
     {atom,1,ets_collector},
     {tuple,1,[{atom,1,insert},{call,1,{atom,1,self},[]}]}}]
```

Transform function!

```
transform_ets_insert({call, Line,
                       {remote, _, {atom, _, ets},
                         {atom, _, insert}},
                       [{atom, _, contentious_table},
                         Objects]}
                     = Form) ->
    {op,Line,'!',
      {atom,Line,ets_collector},
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transform_ets_insert(Form) ->
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```

... well, almost ...

Turn this

```
ets:insert(contentious_table, Objects),
```

Turn this

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ets:insert(contentious_table, Objects),
```

Into this

```
ets_collector ! {insert, self()},
ets:insert(contentious_table, Objects),
```

without changing the *shape* of the parse tree.

replace a single node with a different single node (not a list)

What about this?

```
begin
    ets_collector ! {insert, self()},
    ets:insert(contentious_table, Objects)
end,
```

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✓Single AST node

What about this?

```
begin
    ets_collector ! {insert, self()},
    ets:insert(contentious_table, Objects)
end,
```

✓Single AST node

✓Same expression value

Complete AST node transform

```
transform_ets_insert({call, Line,
                       {remote, _, {atom, _, ets},
                        {atom, _, insert}},
                       [{atom, _, contentious_table}, Objects]}
                     = Form) ->
    {block, Line, [{op,Line,'!',
                    {atom,Line,ets_collector},
                    {tuple,Line,[{atom,Line,insert},
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transform_ets_insert(Form) ->
    Form.
```

Now to use it!

Transform this

```
change_username(UserId, UserName) when UserId =:= 0 ->
  error("Can't change admin user name");
change_username(UserId, UserName) ->
  Users = ets:lookup(contentious_table, UserId),
  [User] = Users,
  case User#user.group of
    luser ->
      error("Insufficient privileges");
    G when G =:= user; G =:= admin ->
      ets:insert(contentious_table, User#user{name = UserName})
  end.
```

```
{function,25,change_username,2,
    [{clause,25,
        [{var,25,'UserId'},{var,25,'UserName'}],
        [[{op,25,'=:=',{var,25,'UserId'},{integer,25,0}}]],
        [{call,26,
              {atom,26,error},
              [{string,26,"Can't change admin user name"}]}]},
    {clause,27,
        [{var,27,'UserId'},{var,27,'UserName'}],
        [],
        [{match,28,
              {var,28,'Users'},
              {call,28,
                  {remote,28,{atom,28,ets},{atom,28,lookup}},
                  [{atom,28,contentious_table},{var,28,'UserId'}]}},
          {match,29,{cons,29,{var,29,'User'},{nil,29}},{var,29,'Users'}},
          {case,30,
              {record_field,30,{var,30,'User'},user,{atom,30,group}},
              [{clause,31,
                  [{atom,31,luser}],
                  [],
                  [{call,32,
                        {atom,32,error},
                        [{string,32,"Insufficient privileges"}]}]},
              {clause,33,
                  [{var,33,'G'}],
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                        {record,34,
                            {var,34,'User'},
                            user,
                            [{record_field,34,
                                  {atom,34,name},
                                  {var,34,'UserName'}}]}]}]}]}]}]}
```

Lets take a step back

Working with Abstract Format

Bring your sword to the dragon fight

Isn't there something to help?

`stdlib`

- epp - Erlang preprocessor (macros and includes)
- erl_scan - Turn text into tokens
- erl_parse - Turn tokens into an AST
- erl_pp - Turn an AST back into text (Pretty Print it)
- erl_eval - Execute ASTs
- erl_id_trans - Identity transform that walks the whole AST

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`syntax_tools`

- erl_prettypr - Another pretty-printer of ASTs
- erl_syntax - Define a 'super-set' of the `stdlib` AST
- erl_syntax_lib - Helper functions for working with ASTs

Common pattern

1. Find an AST node of interest, e.g., a function call
2. Extract context / detail
3. Create a modified node
4. Replace the node with the modified one
5. Do this for all nodes
6. Hand the new AST back to the compiler

erl_syntax_lib

```
map(Fun, AST) -> AST1.

map_fun(AstNode) -> AstNode1.
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```

```
mapfold(Fun, Acc, AST) -> {AST1, Acc1}.

mapfold_fun(Node, Acc) -> {Node1, Acc1}.
```

Complete parse transform

```
parse_transform(Forms, _Options) ->
    Forms1 = [erl_syntax_lib:map(
                fun(Node) ->
                    transform_ets_insert(
                      erl_syntax:revert(Node))
                end,
                F)
              || F <- Forms],
    erl_syntax:revert_forms(Forms1).

transform_ets_insert({call, Line,
                       {remote, _, {atom, _, ets},
                         {atom, _, insert}},
                       [{atom, _, contentious_table}, _Objects]}
                     = Form) ->
    {block, Line, [{op,Line,'!',
                    {atom,Line,ets_collector},
                    {tuple,Line,[{atom,Line,insert},
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A module is a list of trees (not a tree of trees)

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`erl_syntax_lib` has a different AST

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- Quite complex - requires a deep understanding of the Erlang grammar
- Abstract Format can change as the language evolves
- Your bug just became a compiler bug
- Slows down compilation
- Code becomes difficult or impossible to reason about

Parse transforms in the wild

Another Erlang to Object Notation translator*

(aeon) https://github.com/garret-smith/aeon

```
-record(user, {
          name :: binary(),
          height :: float(),
          birthday :: {Year :: integer(),
                       Month :: integer(),
                       Day :: integer()},
          privileges :: [privilege()]
         }).
```

```
User = #user{
          name = <<"Garret Smith">>,
          height = 6.0,
          birthday = {1982, 06, 29},
          privileges = [login, create, delete, grant]
         },
Json = jsx:encode(aeon:record_to_jsx(User, ?MODULE)),
User1 = aeon:to_record(jsx:decode(Json), ?MODULE, user),
User = User1
```

```
{
  "name":"Garret Smith",
  "height":6.0,
  "birthday":[1982,6,29],
  "privileges":["login","create","delete","grant"]
}
```

*I wrote it

aeon Parse Transform

```
-include_lib("parse_trans/include/codegen.hrl").

parse_transform(Forms, Options) ->
    parse_trans:top(fun do_transform/2, Forms, Options).

do_transform(Forms, Context) ->
    F = erl_syntax_lib:analyze_forms(Forms),
    case lists:keyfind(attributes, 1, F) of
        false -> Forms;
        {K, R} ->
            Attr = lists:flatten([transform_attribute(A) || A<-R]),
            Func = codegen:gen_function(
                        ?FUN_NAME, fun() -> {'$var', Attr} end),
            Forms2 = parse_trans:do_insert_forms(below, [Func],
                                                 Forms, Context),
            Forms3 = parse_trans:export_function(?FUN_NAME,
                                                 0, Forms2),
            parse_trans:revert(Forms3)
    end.
```

parse_trans

https://github.com/uwiger/parse_trans.git

- Convenience functions for common cases.
- Error handling for your transform (you will want this)
- codegen: A parse transform for your parse transform.
- Create new functions or entire modules from thin air.

parse_trans

https://github.com/uwiger/parse_trans.git

- Convenience functions for common cases.
- Error handling for your transform (you will want this)
- codegen: A parse transform for your parse transform.
- Create new functions or entire modules from thin air.
- exprecs, generate and export accessor functions for record fields.

lager (as in beer)

https://github.com/basho/lager.git

Turn the log statement `lager:info("~s", ["hello"])` into:

```
case {whereis(lager_event), whereis(lager_event),
      lager_config:get({lager_event, loglevel}, {0, []})}
    of
  {undefined, undefined, _} ->
      fun () -> {error, lager_not_running} end();
  {undefined, _, _} ->
      fun () -> {error, {sink_not_configured, lager_event}}
      end();
  {__Pidlager_test6, _,
   {__Levellager_test6, __Traceslager_test6}}
      when __Levellager_test6 band 64 /= 0 orelse
             __Traceslager_test6 /= [] ->
      lager:do_log(info,
                   [{module, lager_test}, {function, say_hello}, {line, 6},
                    {pid, pid_to_list(self())}, {node, node()}
                    | lager:md()],
                   "~s", ["hello"], 4096, 64, __Levellager_test6,
                   __Traceslager_test6, lager_event, __Pidlager_test6);
  _ -> ok
end
```

PARE - PARallel Execution in Erlang

http://chlorophil.blogspot.com/2007/11/pare-parallel-execution-in-erlang.html

Basic idea: embed atoms to automatically parallelize execution of sequential code.

```
parallel_next_3,
A = a(),
b(),
c(),
```

seqbind

https://github.com/spawngrid/seqbind

```
V1 = foo(V),
V2 = bar(V1),
V3 = baz(V2)
```

```
V@ = foo(V),
V@ = bar(V@),
V@ = baz(V@)
```

Zen of parse transforms

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- *raw speed*, where the time invested in optimization pays off because of widespread reuse (lager).

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- Extend Erlang with new, custom semanics (seqbind).
- Experimentation with new language semantics. Easier than writing a compiler (PARE).
- Metaprogramming is it's own reward (inline transform)!

A parse transform enabling inline module transforms!

```
parse_transform(Forms, Options) ->
    {[InlineTransform], RemainingForms} =
        lists:partition(
          fun({function, _, inline_transform, 2, _}) -> true;
             (_) -> false
          end,
          Forms),
    TransformerExpressions = extract_exprs(InlineTransform),

    {value, Transformed, _Vars} =
        erl_eval:exprs(TransformerExpressions,
                       orddict:from_list([{'Forms', RemainingForms},
                                          {'Options', Options}])),
    erl_syntax:revert_forms(Transformed).

extract_exprs({function, _Line, _Name, _Arity, Clauses}) ->
    {clause, _, _Args, _When, Exprs} = hd(Clauses),
    Exprs.
```

pull the 'inline_transform' function out of the AST

```
parse_transform(Forms, Options) ->
    {[InlineTransform], RemainingForms} =
        lists:partition(
          fun({function, _, inline_transform, 2, _}) -> true;
             (_) -> false
          end,
          Forms),
    TransformerExpressions = extract_exprs(InlineTransform),

    {value, Transformed, _Vars} =
        erl_eval:exprs(TransformerExpressions,
                       orddict:from_list([{'Forms', RemainingForms},
                                          {'Options', Options}])),
    erl_syntax:revert_forms(Transformed).

extract_exprs({function, _Line, _Name, _Arity, Clauses}) ->
    {clause, _, _Args, _When, Exprs} = hd(Clauses),
    Exprs.
```

Extract the body of the transform

```
parse_transform(Forms, Options) ->
    {[InlineTransform], RemainingForms} =
        lists:partition(
          fun({function, _, inline_transform, 2, _}) -> true;
             (_) -> false
          end,
          Forms),
    TransformerExpressions = extract_exprs(InlineTransform),

    {value, Transformed, _Vars} =
        erl_eval:exprs(TransformerExpressions,
                       orddict:from_list([{'Forms', RemainingForms},
                                          {'Options', Options}])),
    erl_syntax:revert_forms(Transformed).

extract_exprs({function, _Line, _Name, _Arity, Clauses}) ->
    {clause, _, _Args, _When, Exprs} = hd(Clauses),
    Exprs.
```

eval the body against the remaining AST Forms

```
parse_transform(Forms, Options) ->
    {[InlineTransform], RemainingForms} =
        lists:partition(
          fun({function, _, inline_transform, 2, _}) -> true;
             (_) -> false
          end,
          Forms),
    TransformerExpressions = extract_exprs(InlineTransform),

    {value, Transformed, _Vars} =
        erl_eval:exprs(TransformerExpressions,
                       orddict:from_list([{'Forms', RemainingForms},
                                          {'Options', Options}])),
    erl_syntax:revert_forms(Transformed).

extract_exprs({function, _Line, _Name, _Arity, Clauses}) ->
    {clause, _, _Args, _When, Exprs} = hd(Clauses),
    Exprs.
```

ETS collector as inline transform

```
inline_transform(Forms, Options) ->
    [erl_syntax_lib:map(
       fun(Node) ->
               case erl_syntax:revert(Node) of
                   {call, Line, {remote, _,
                                 {atom, _, ets},
                                 {atom, _, insert}},
                    [{atom, _, contentious_table},
                     _Objects]} = Form ->
                       {block, Line,
                        [{op,Line,'!',
                          {atom,Line,ets_collector},
                          {tuple,Line,[{atom,Line,insert},
                                       {call,Line,
                                        {atom,Line,self},[]}]}},
                         Form]};
                   Form -> Form
               end
       end,
       F)
     || F <- Forms].
```

All inline - no sub-functions

```
inline_transform(Forms, Options) ->
    [erl_syntax_lib:map(
       fun(Node) ->
               case erl_syntax:revert(Node) of
                   {call, Line, {remote, _,
                                 {atom, _, ets},
                                 {atom, _, insert}},
                    [{atom, _, contentious_table},
                     _Objects]} = Form ->
                       {block, Line,
                        [{op,Line,'!',
                          {atom,Line,ets_collector},
                          {tuple,Line,[{atom,Line,insert},
                                       {call,Line,
                                        {atom,Line,self},[]}]}},
                         Form]};
                   Form -> Form
               end
       end,
       F)
     || F <- Forms].
```

Thanks
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