A PropEr Talk

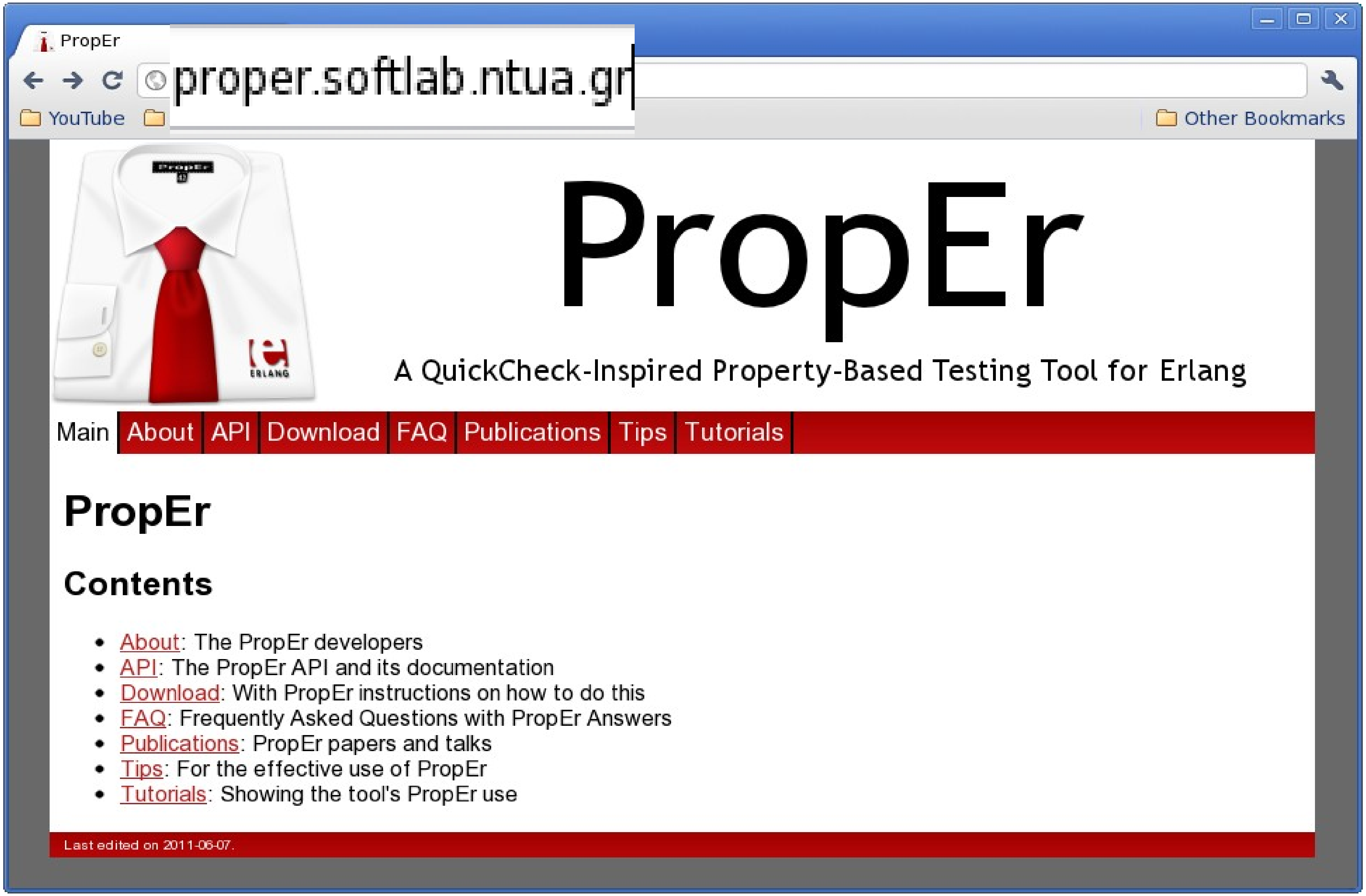
Kostis Sagonas

With PropEr help by

Manolis Papadakis

Eirini Arvaniti

A PropEr announcement



PropEr

proper.softlab.ntua.gr

YouTube

Other Bookmarks

PropEr

A QuickCheck-Inspired Property-Based Testing Tool for Erlang

Main | About | API | Download | FAQ | Publications | Tips | Tutorials

PropEr

Contents

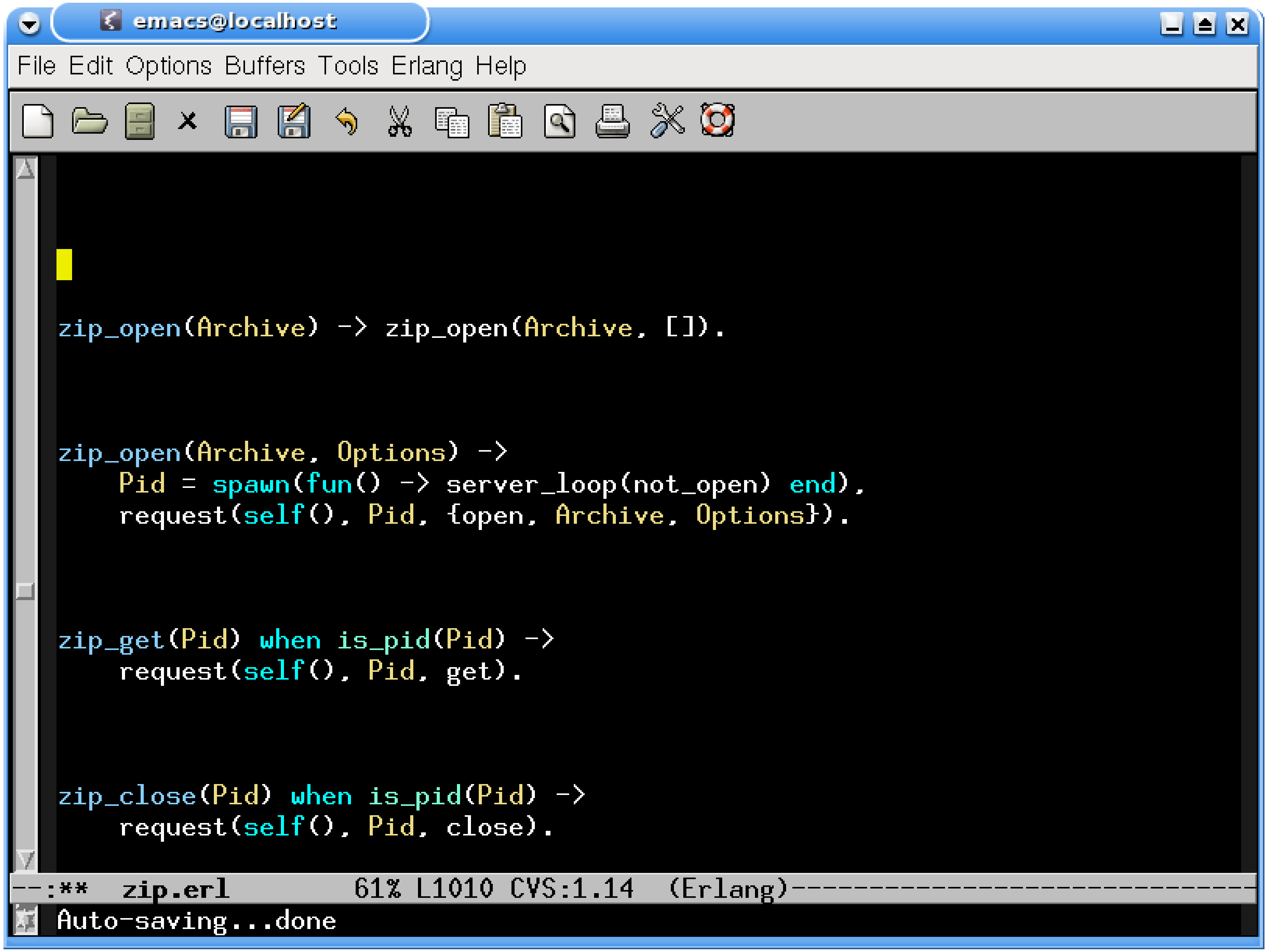
- About: The PropEr developers
- API: The PropEr API and its documentation
- Download: With PropEr instructions on how to do this
- FAQ: Frequently Asked Questions with PropEr Answers
- Publications: PropEr papers and talks
- Tips: For the effective use of PropEr
- Tutorials: Showing the tool's PropEr use

Last edited on 2011-06-07.

A PropEr question

Why did you create PropEr?

How Erlang modules used to look



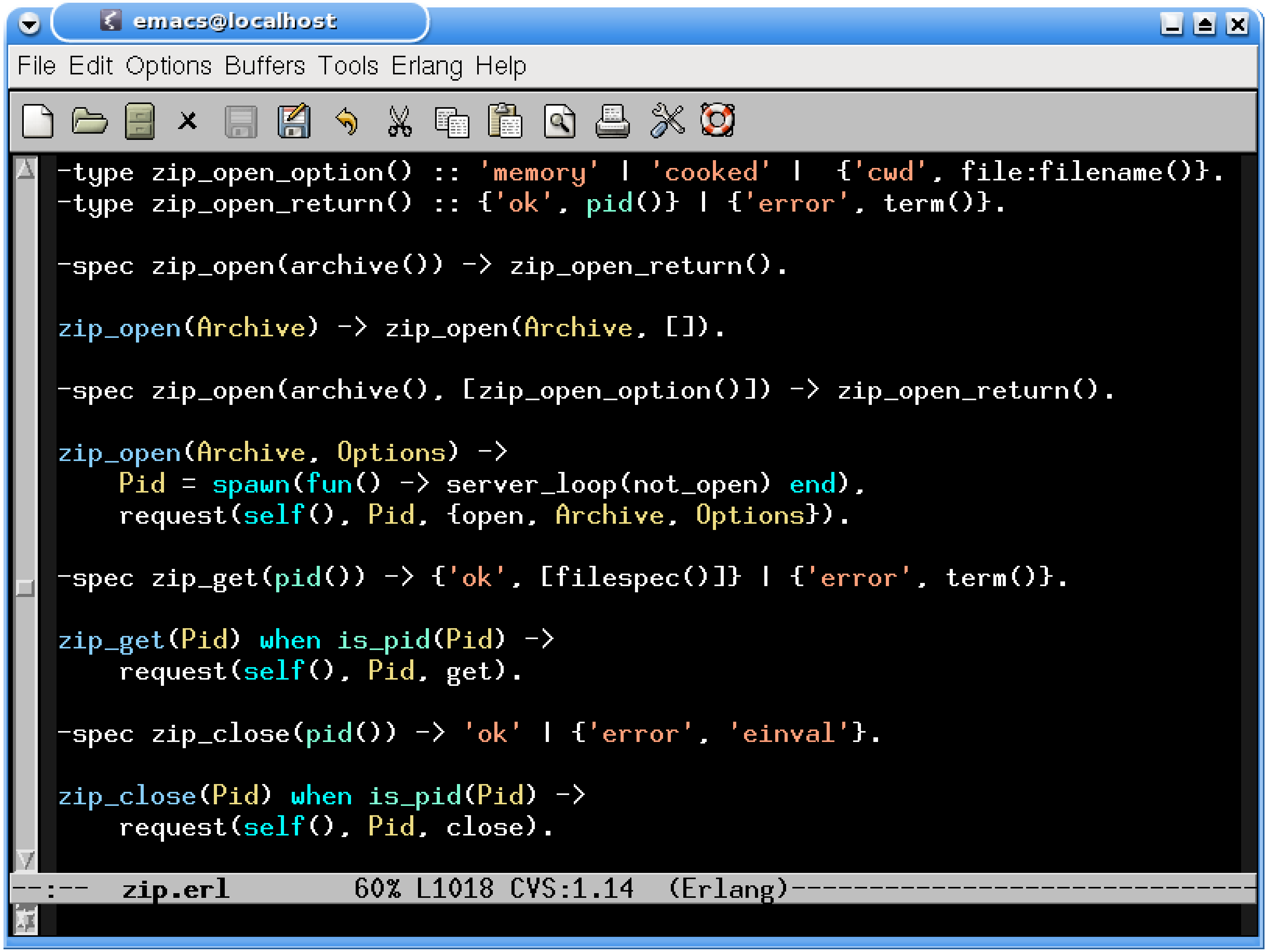
```
zip_open(Archive) -> zip_open(Archive, []).


zip_open(Archive, Options) ->
    Pid = spawn(fun() -> server_loop(not_open) end),
    request(self(), Pid, {open, Archive, Options}).


zip_get(Pid) when is_pid(Pid) ->
    request(self(), Pid, get).


zip_close(Pid) when is_pid(Pid) ->
    request(self(), Pid, close).
--:**  zip.erl        61% L1010 CVS:1.14   (Erlang)------------------------------
Auto-saving...done
```

How modern Erlang modules look



```
-type zip_open_option() :: 'memory' | 'cooked' |  {'cwd', file:filename()}.
-type zip_open_return() :: {'ok', pid()} | {'error', term()}.

-spec zip_open(archive()) -> zip_open_return().

zip_open(Archive) -> zip_open(Archive, []).

-spec zip_open(archive(), [zip_open_option()]) -> zip_open_return().

zip_open(Archive, Options) ->
    Pid = spawn(fun() -> server_loop(not_open) end),
    request(self(), Pid, {open, Archive, Options}).

-spec zip_get(pid()) -> {'ok', [filespec()]} | {'error', term()}.

zip_get(Pid) when is_pid(Pid) ->
    request(self(), Pid, get).

-spec zip_close(pid()) -> 'ok' | {'error', 'einval'}.

zip_close(Pid) when is_pid(Pid) ->
    request(self(), Pid, close).
--:--  zip.erl      60% L1018 CVS:1.14   (Erlang)--------------------------------
```

A PropEr start...

MANOLIS, HAVE YOU EVER HEARD OF SOMETHING CALLED QUICK-CHECK?
IT IS ESSENTIALLY BLABLABLA
I WANT TO COMBINE IT WITH ERLANG'S TYPE LANGUAGE! IT'S A GREAT DIPLOMA THESIS TOPIC!
I KNOW YOU BY NOW, WHAT'S THE CATCH?
WELL, QUICKCHECK IS CLOSED SOURCE, SO WE HAVE TO IMPLEMENT THE WHOLE THING FIRST
JORGE CHAM © 2005
www.phdcomics.com

PropEr progress four months later

IT HAS TAKEN ME A LONG TIME,
BUT I FINALLY FINISHED THE IMPLEMENTA-TION
GOOD JOB! THIS WILL DO AS A BASIS
NOW IT'S TIME TO START WORKING ON YOUR THESIS TOPIC
4 MONTHS OF WORK AND I HAVEN'T EVEN STARTED YET?
THAT'S RIGHT
JORGE CHAM © 2010
WWW.PHDCOMICS.COM

PropEr: A property-based testing tool

- Inspired by QuickCheck
- Available open source under GPL
- Has support for
  - Writing properties and test case generators

    `?FORALL/3, ?IMPLIES, ?SUCHTHAT/3, ?SHRINK/2, ?LAZY/1, ?WHENFAIL/2, ?LET/3, ?SIZED/2, aggregate/2, choose2, oneof/1, ...`
  - Concurrent/parallel “statem” and “fsm” testing
- Fully integrated with the language of types and specs
  - Generators often come for free!

Testing simple properties (1)

```erlang
-module(simple_props).

%% Properties are automatically exported.
-include_lib("proper/include/proper.hrl").

%% Functions that start with prop_ are considered properties
prop_t2b_b2t() ->
  ?FORALL(T, term(), T =:= binary_to_term(term_to_binary(T))).
```

```
1> c(simple_props).
{ok,simple_props}
2> proper:quickcheck(simple_props:prop_t2b_b2t()).
..................................................
..................................................
OK: Passed 100 test(s)
true
```

Testing simple properties (2)

```erlang
%% Testing the base64 module:
%%   encode should be symmetric to decode:

prop_enc_dec() ->
  ?FORALL(Msg, union([binary(), list(range(1,255))]),
      begin
        EncDecMsg = base64:decode(base64:encode(Msg)),
        case is_binary(Msg) of
          true  -> EncDecMsg =:= Msg;
          false -> EncDecMsg =:= list_to_binary(Msg)
        end
      end).
```

PropEr integration with simple types

```
%% Using a user-defined simple type as a generator
-type bl() :: binary() | [1..255].

prop_enc_dec() ->
  ?FORALL(Msg, bl(),
      begin
        EncDecMsg = base64:decode(base64:encode(Msg)),
        case is_binary(Msg) of
          true  -> EncDecMsg =:= Msg;
          false -> EncDecMsg =:= list_to_binary(Msg)
        end
      end).
```

PropEr shrinking

```erlang
%% A lists delete implementation
-spec delete(T, list(T)) -> list(T).
delete(X, L) ->
  delete(X, L, []).

delete(_, [], Acc) ->
  lists:reverse(Acc);
delete(X, [X|Rest], Acc) ->
  lists:reverse(Acc) ++ Rest;
delete(X, [Y|Rest], Acc) ->
  delete(X, Rest, [Y|Acc]).
```

```erlang
prop_delete() ->
  ?FORALL({X,L}, {integer(),list(integer())},
          not lists:member(X, delete(X, L))).
```

PropEr shrinking

```
41> c(simple_props).
{ok,simple_props}
42> proper:quickcheck(simple_props:prop_delete()).
..........................................!
Failed: After 42 test(s).
{12,[-36,-1,-2,7,19,-14,40,-6,-8,42,-8,12,12,-17,3]}

Shrinking ...(3 time(s))
{12,[12,12]}
false
```

PropEr integration with types

```
-type tree(T) :: 'leaf' | {'node',T,tree(T),tree(T)}.
```

```
%% A tree delete implementation
-spec delete(T, tree(T)) -> tree(T).
delete(X, leaf) ->
  leaf;
delete(X, {node,X,L,R}) ->
  join(L, R);
delete(X, {node,Y,L,R}) ->
  {node,Y,delete(X,L),delete(X,R)}.
```

```
join(leaf, T) -> T;
join({node,X,L,R}, T) ->
   {node,X,join(L,R),T}.
```

```
prop_delete() ->
   ?FORALL({X,L}, {integer(),tree(integer())},
              not lists:member(X, delete(X, L))).
```

What one would have to write in EQC

```
tree(G) ->
  ?SIZED(S, tree(S, G)).

tree(0, _) ->
  leaf;
tree(S, G) ->
  frequency([
    {1, tree(0, G)},
    {9, ?LAZY(
            ?LETSHRINK(
              [L,R],
              [tree(S div 2, G),tree(S div 2, G)],
              {node,G,L,R}
        ))}
  ]).
```

What one has to write in PropEr

This slide intentionally left blank

PropEr testing of specs

```
-module(myspecs).

-export([divide/2, filter/2, max/1]).

-spec divide(integer(), integer()) -> integer().
divide(A, B) ->
  A div B.

-spec filter(fun((T) -> term()), [T]) -> [T].
filter(Fun, List) ->
  lists:filter(Fun, List).

-spec max([T]) -> T.
max(List) ->
  lists:max(List).
```

PropEr testing of specs

```
1> c(myspecs).
{ok,myspecs}
2> proper:check_spec({myspecs,divide,2}).
!
Failed: After 1 test(s).
An exception was raised: error:badarith.
Stacktrace: [{myspecs,divide,2}].
[0,0]

Shrinking (0 time(s))
[0,0]
false
      .... AFTER FIXING THE PROBLEMS ....
42> proper:check_specs(myspecs).
```

PropEr integration with remote types

- We want to test that **`array:new/0`** can handle any combination of options
- Why write a custom generator (which may rot)?
- We can use the remote type as a generator!

```
-type array_opt()  :: 'fixed' | non_neg_integer()
                    | {'default', term()}
                    | {'fixed', boolean()}
                    | {'size', non_neg_integer()}.
-type array_opts() :: array_opt() | [array_opt()].
```

```
-module(types).
-include_lib("proper/include/proper.hrl").

prop_new_array_opts() ->
   ?FORALL(Opts, array:array_opts(),
           array:is_array(array:new(Opts))).
```

PropEr testing of stateful systems

- PropEr can be used to test these as well
  - We simply have to define a callback for the PropEr **`statem`** or **`fsm`** behavior

- What are these behaviors?
  - Libraries that can be used to test a system by generating and performing API calls to that system

- The callback module specifies a PropEr abstract model of the system under test

PropEr testing of stateful systems

- PropEr `statem` or `fsm` libraries
  - automatically generate test cases from the model and
  - execute them to test the real implementation against the model
- However, the test cases should be generated strictly *before* they are run
  - otherwise, they are not repeatable and we cannot shrink them

PropEr statem testing of pdict

Intention: test **`put/2`**, **`get/1`**, **`erase/1`** operations

Test cases are sequences of symbolic API calls

```
command([]) ->
  {call, erlang, put, [key(), integer()]};
command(_State) ->
  oneof([{call, erlang, put, [key(), integer()]},
         {call, erlang, get, [key()]},
         {call, erlang, erase, [key()]}]).
```

```
-define(KEYS, [a,b,c,d]).

key() ->
  elements(?KEYS).
```

PropEr commands

- We have put a rule: first generate, then execute
- What if we need to use the result of a previous call in a subsequent one?

Commands to the rescue!

- PropEr automatically binds the result of each symbolic call to a symbolic variable

```
[{set, {var,1}, {call, erlang, put, [a,42]}},
 {set, {var,2}, {call, erlang, erase, [a]}},
 {set, {var,3}, {call, erlang, put, [b,{var,2}]}}]
```

The PropEr model states

- A model of the system's internal state (at least of the useful part of it!)
- We model the process dictionary as a property list

```
initial_state() -> [].

next_state(State, _Result, {call,erlang,put,[Key,Value]}) ->
  State ++ [{Key,Value}];
next_state(State, _Result, {call,erlang,erase,[Key]}) ->
  proplists:delete(Key, State);
next_state(State, _Result, {call,erlang,get,[_Key]}) ->
  State.
```

PropEr pre- and post- conditions

```
precondition(_, {call,erlang,put,[_Key,_Val]}) ->
  true;
precondition(State, {call,erlang,get,[Key]}) ->
  proplists:is_defined(Key, State);
precondition(State, {call,erlang,erase,[Key]}) ->
  proplists:is_defined(Key, State).
```

```
postcondition(State, {call,erlang,put,[Key,_]}, undefined) ->
  not proplists:is_defined(Key, State);
postcondition(State, {call,erlang,put,[Key,_Val]}, Old) ->
  {Key,Old} =:= proplists:lookup(Key, State);
postcondition(State, {call,erlang,get,[Key]}, Val) ->
  {Key,Val} =:= proplists:lookup(Key, State);
postcondition(State, {call,erlang,erase,[Key]}, Val) ->
  {Key,Val} =:= proplists:lookup(Key, State);
postcondition(_, _, _) ->
  false.
```

A PropEr property for pdict...

random symbolic command sequence generator

evaluate the command sequence

```
prop_pdict() ->
  ?FORALL(Cmds, commands(?MODULE),
          begin
            {Hist,State,Res} = run_commands(?MODULE, Cmds),
            clean_up(),
            ?WHENFAIL(io:format("H: ~w\nSt: ~w\nRes: ~w\n",
                                [Hist, St
                      Res =:= ok)
          end).

clean_up() ->
  lists:foreach(fun(Key) -> erlang:erase(Key) end, ?KEYS).
```

the PropEr thing to do...

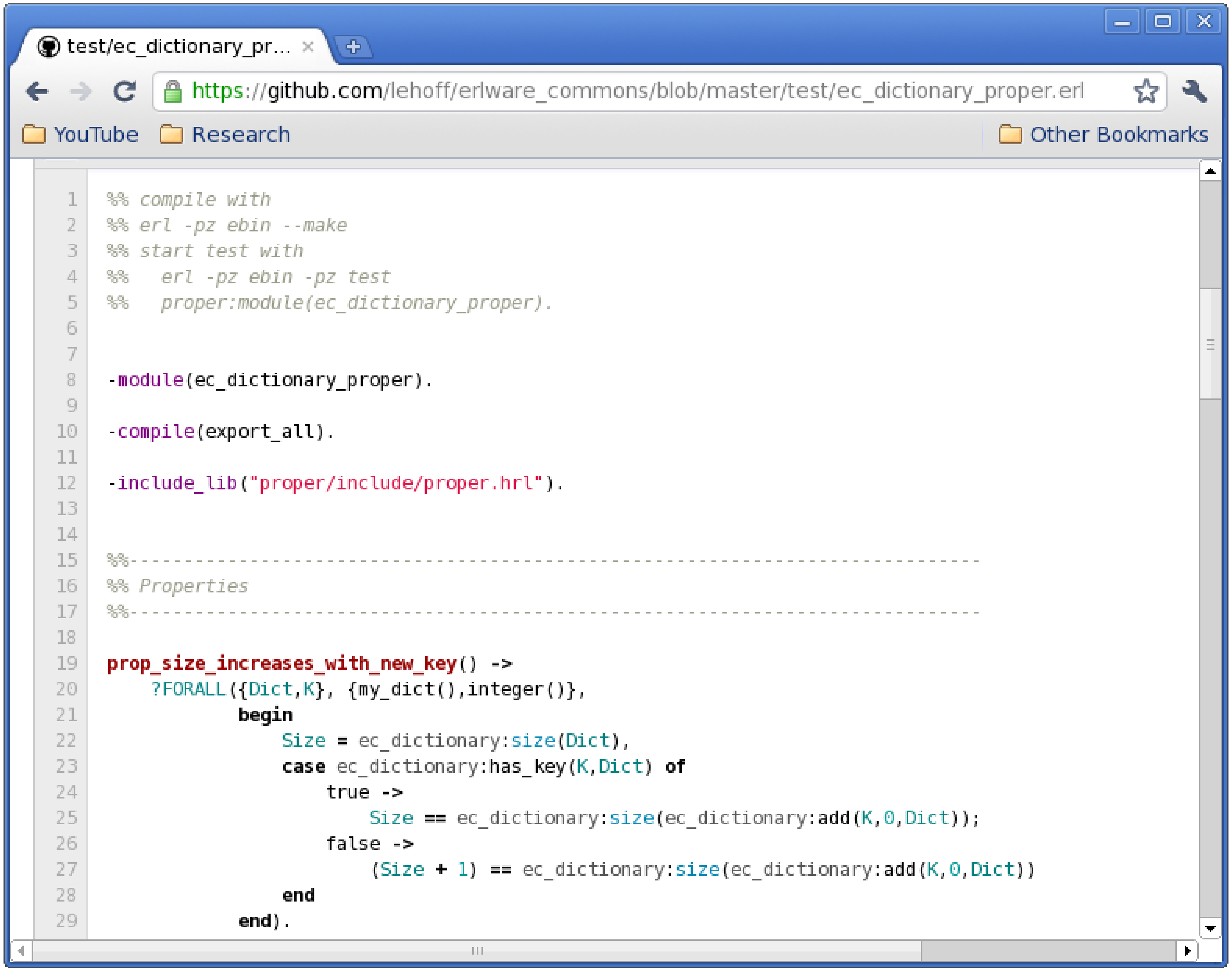
tests pass when no exception is raised and all postconditions are true

...with a PropEr failure

```
42> proper:quickcheck(pdict_statem:prop_pdict()).
............!
Failed: After 13 test(s).
[{set,{var,1},{call,erlang,put,[a,-12]}},{set,{var,2},{call,erlang,put,[a,-18]}},
 {set,{var,3},{call,erlang,put,[c,4]}},{set,{var,4},{call,erlang,put,[b,6]}},
 {set,{var,5},{call,erlang,erase,[b]}},{set,{var,6},{call,erlang,put,[d,39]}},
 {set,{var,7},{call,erlang,get,[a]}}]
H: [{[],undefined},{[{a,-12}],-12},{[{a,-12},{a,-18}],undefined},{[{a,-12},
{a,-18},{c,4}],undefined},{[{a,-12},{a,-18},{c,4},{b,6}],6},{[{a,-12},{a,-18},
{c,4}],undefined},{[{a,-12},{a,-18},{c,4},{d,39}],-18}]
St: [{a,-12},{a,-18},{c,4},{d,39}]
Res: {postcondition,false}
```

```
Shrinking ....(4 time(s))
[{set,{var,1},{call,erlang,put,[a,-12]}},
 {set,{var,2},{call,erlang,put,[a,-18]}},
 {set,{var,7},{call,erlang,get,[a]}}]
H: [{[],undefined},{[{a,-12}],-12},{[{a,-12},{a,-18}],-18}]
St: [{a,-12},{a,-18}]
Res: {postcondition,false}
false
```

PropEr already used out there!


test/ec_dictionary_pr...

https://github.com/lehoff/erlware_commons/blob/master/test/ec_dictionary_proper.erl

YouTube Research Other Bookmarks

```erlang
%% compile with
%% erl -pz ebin --make
%% start test with
%%   erl -pz ebin -pz test
%%   proper:module(ec_dictionary_proper).


-module(ec_dictionary_proper).

-compile(export_all).

-include_lib("proper/include/proper.hrl").


%%-------------------------------------------------------------------------------
%% Properties
%%-------------------------------------------------------------------------------

prop_size_increases_with_new_key() ->
    ?FORALL({Dict,K}, {my_dict(),integer()},
            begin
                Size = ec_dictionary:size(Dict),
                case ec_dictionary:has_key(K,Dict) of
                    true ->
                        Size == ec_dictionary:size(ec_dictionary:add(K,0,Dict));
                    false ->
                        (Size + 1) == ec_dictionary:size(ec_dictionary:add(K,0,Dict))
                end
            end).
```

Quote from a PropEr user

“I ran PropEr using statem on a real example which I already had for EQC. It was just to switch include file, recompile and run!”

Property-based testing by experts

From: **Ulf Wiger** on **erlang-questions**

Date: 16/3/2011, 18:13

When I use ordered_set ets over gb_trees it has more than once been due to the fact that you can do wonderful stuff with first, next, prev and last - and gb_trees doesn't have them.

I've made a stab at implementing these functions for the gb_trees data structure, together with a quickcheck spec to verify that they work as expected (you can use eqc mini to run the tests). I think they are reasonably efficient, but perhaps someone can think of a way to optimize them?

Have at it, and pls use the spec to verify that you didn't break them (recalling that an incorrect program can be made arbitrarily fast)

Code from Ulf Wiger

```erlang
-module(gb1).
-compile(export_all).

-include_lib("eqc/include/eqc.hrl").

gb_next(K, {_, T}) ->
    gb_next_1(K, T).

gb_next_1(K, {K1, _, Smaller, Bigger}) when K < K1 ->
    case gb_next_1(K, Smaller) of
      none ->
         case gb_next_1(K, Bigger) of
           none ->
              {value, K1};
           {value, K2} ->
              {value, erlang:min(K1, K2)}
         end;
      {value, _} = Res ->
         Res
    end;
gb_next_1(K, {K1, _, _, Bigger}) when K > K1 ->
    gb_next_1(K, Bigger);
gb_next_1(K, {_, _, _, Bigger}) ->
    case Bigger of
      nil ->
         none;
      {K1, _, Smaller, _} ->
         case gb_next_1(K, Smaller) of
           none ->
              {value, K1};
           {value, _} = Res ->
              Res
         end
    end;
gb_next_1(_, nil) ->
    none.
```

```erlang
gb_prev(K, {_, T}) ->
    gb_prev_1(K, T).

gb_prev_1(K, {K1, _, Smaller, Bigger}) when K > K1 ->
    case gb_prev_1(K, Bigger) of
      none ->
         case gb_prev_1(K, Smaller) of
            none ->
              {value, K1};
           {value, K2} ->
              {value, erlang:max(K1, K2)}
         end;
      {value, _} = Res ->
         Res
    end;
gb_prev_1(K, {K1, _, Smaller, _}) when K < K1 ->
    gb_prev_1(K, Smaller);
gb_prev_1(K, {_, _, Smaller, _}) ->
    case Smaller of
      nil ->
         none;
      {K1, _, _, Bigger} ->
         case gb_prev_1(K, Bigger) of
           none ->
              {value, K1};
           {value, _} = Res ->
              Res
         end
    end;
gb_prev_1(_, nil) ->
    none.
```

More code from Ulf Wiger

```
first({_, T}) ->
    first_1(T).

first_1({K,_,nil,_}) ->
    {value, K};
first_1({_,_,Smaller,_}) ->
    first_1(Smaller);
first_1(nil) ->
    none.

last({_, T}) ->
    last_1(T).

last_1({K,_,_,nil}) ->
    {value, K};
last_1({_,_,_,Bigger}) -
    last_1(Bigger);
last_1(nil) ->
    none.
```

```
all_next([X], T) ->
    {X,none} = {X,gb_next(X, T)},
    ok;
all_next([A,B|Rest], T) ->
    {A,{value,B}} = {A,gb_next(A, T)},
    all_next([B|Rest], T);
all_next([], _) ->
    ok.

all_prev([X], T) ->
    {X,none} = {X,gb_prev(X, T)},
    ok;
all_prev([A,B|Rest], T) ->
    {A,{value,B}} = {A,gb_prev(A, T)},
    all_prev([B|Rest], T);
all_prev([], _) ->
    ok.
```

```
make_tree(L) ->
    T = lists:foldl(fun(X,T) ->
                         gb_trees:enter(X,1,T)
                    end, gb_trees:empty(), L),
    Sorted = [K || {K,_} <- gb_trees:to_list(T)],
    {T, Sorted}.
```

```
prop_first() ->
    ?FORALL(L, list(int()),
            begin
               {T, Sorted} = make_tree(L),
               case first(T) of
                  none -> Sorted == [];
                  {value,X} -> X == hd(Sorted)
               end
            end).

prop_last() ->
    ?FORALL(L, list(int()),
            begin
               {T, Sorted} = make_tree(L),
               case last(T) of
                  none -> Sorted == [];
                  {value,X} -> X == lists:last(Sorted)
               end
         end).

     prev() ->
     FORALL(L, list(int()),
            begin
                {T, Sorted} = make_tree(L),
                ok == all_prev(lists:reverse(Sorted), T)
            end).

prop_next() ->
    ?FORALL(L, list(int()),
            begin
                {T, Sorted} = make_tree(L),
                ok == all_prev(lists:reverse(Sorted), T)
            end).
```

A closer look at the code

```
-module(gb1).
-compile(export_all).

-include_lib("eqc/include/eqc.hrl").

gb_next(K, {_, T}) ->
    gb_next_1(K, T).
```

A better version

```
-module(gb1).
-export([gb_next/2, gb_prev/2,
         first/1, last/1]).

-include_lib("eqc/include/eqc.hrl").

-spec gb_next(term(), gb_tree()) ->
          'none' | {'value', term()}.

gb_next(K, {_, T}) ->
    gb_next_1(K, T).
```

A PropEr version

```
-module(gb1).
-export([gb_next/2, gb_prev/2,
         first/1, last/1]).

-include_lib("proper/include/proper.hrl").

-spec gb_next(term(), gb_tree()) ->
          'none' | {'value', term()}.

gb_next(K, {_, T}) ->
    gb_next_1(K, T).
```

A closer look at the properties

```
prop_next() ->
   ?FORALL(L, list(int()),
           begin
              {T, Sorted} = make_tree(L),
              ok == all_prev(lists:reverse(Sorted), T)
           end).
```

```
make_tree(L) ->
   T = lists:foldl(fun(X,T) ->
                           gb_trees:enter(X,1,T)
                       end, gb_trees:empty(), L),
   Sorted = [K || {K,_} <- gb_trees:to_list(T)],
   {T, Sorted}.
```

Comments from a guru

From: **John Hughes** on **erlang-questions**

Date: 16/3/2011, 20:58

Nice!

Slight typo: you tested prev twice... your prop_next actually tested prev, it's a copy-and-paste of prop_prev without the renaming to next!

One drawback of your approach is that you only test next and prev on gb_trees constructed using **`empty`** and **`enter`**. Conceivably the other functions could create gb_trees with a different structure that you might fail on.

Here's some code that uses ALL of the constructors to build the test data (no bugs found though!).

Code from a guru

From: **John Hughes** on **erlang-questions**

```
%% gb_tree constructors

gb() ->
  ?SIZED(Size,
         frequency([{1,{call,gb_trees,empty,[]}},
                    {1,{call,gb_trees,
                        from_orddict,[orddict()]}},
                    {Size,?LAZY(compound_gb())}])).
```

More code from a guru

From: **John Hughes** on **erlang-questions**

```
compound_gb() ->
  ?LETSHRINK([GB], [gb()],
             oneof([{call,gb_trees,Fun,Args++[GB]}
                    || [Fun|Args] <-
                         lists:map(fun tuple_to_list/1,
                                   gb_constructors())]
                   ++
                    [{call,erlang,element,
                      [3,{call,gb_trees,
                          take_smallest,[GB]}]},
                     {call,erlang,element,
                      [3,{call,gb_trees,
                          take_largest,[GB]}]}])).
```

Even more code from a guru

From: **John Hughes** on **erlang-questions**

```
gb_constructors() ->
   [{balance},
    {delete,key()},
    {delete_any,key()},
    {enter,key(),val()},
    {insert,key(),val()},
    {update,key(),val()}].

key() ->
   nat().

val() ->
   int().

orddict() ->
   ?LET(L, list({key(),val()}),
        orddict:from_list(L)).
```

The PropEr solution

Why not just write this?

```
prop_next() ->
   ?FORALL(T, gb_tree(key(),val()),
              ok == all_next(gb_trees:keys(T), T)).
```

Compare with:

```
prop_next()
   ?FORALL(I
          k

          e
```

```
%% gb_tree constructors

gb() ->
  ?SIZED(Size,
         frequency([{1,{call,gb_trees,empty,[]}},
                    {1,{call,gb_trees,from_orddict,[orddict()]}},
                    ze,?LAZY(compound_gb())}])).
```

```
,
l,gb_trees,Fun,Args++[GB]}
Fun|Args] <-
  lists:map(fun tuple_to_list/1,gb_constructors())]

ll,erlang,element,
,{call,gb_trees,take_smallest,[GB]}]},
ll,erlang,element,
,{call,gb_trees,take_largest,[GB]}]}])).
```

```
gb_constructors() ->
   [{balance},
    {delete,key()},
    {delete_any,key()},
    {enter,key(),val()},
    {insert,key(),val()},
    {update,key(),val()}].

key() ->
   nat().

val() ->
   int().

orddict() ->
   ?LET(L, list({key(),val()}),
        orddict:from_list(L)).
```

Is this really all?

Yes, but we recommend that you also write:

```
-type key() :: integer().
-type val() :: integer().
```

Do I **really** need to write these type declarations?

Well, no. You could write the property as:

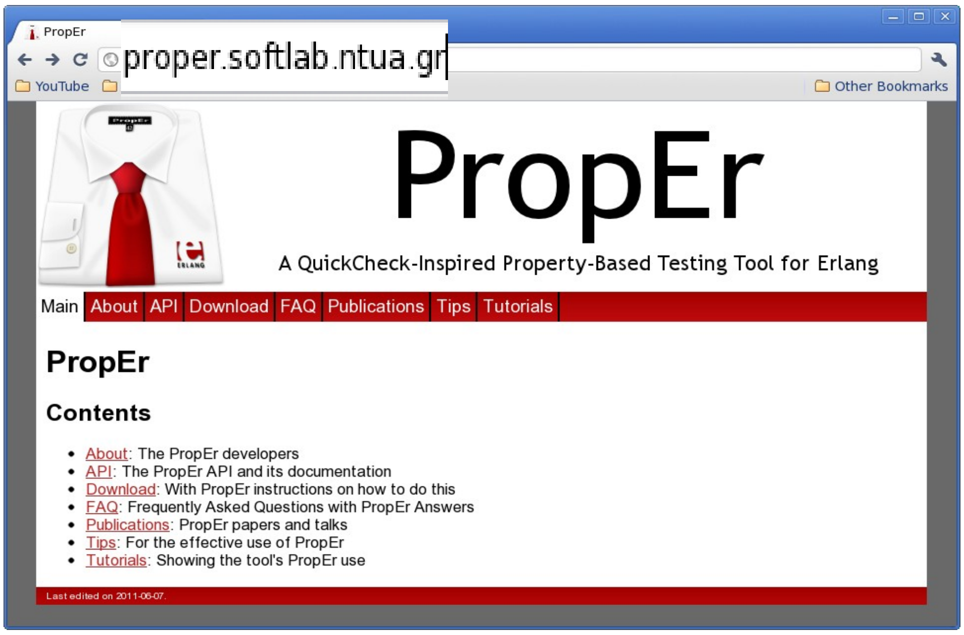
```
prop_next() ->
  ?FORALL(T, gb_tree(integer(),integer()),
          ok == all_next(gb_trees:keys(T), T)).
```

I do not believe this...

OK, let’s do a demo...

Thanks from the PropEr developers!

A PropEr announcement



PropEr

A QuickCheck-Inspired Property-Based Testing Tool for Erlang

Main | About | API | Download | FAQ | Publications | Tips | Tutorials

PropEr

Contents

- About: The PropEr developers
- API: The PropEr API and its documentation
- Download: With PropEr instructions on how to do this
- FAQ: Frequently Asked Questions with PropEr Answers
- Publications: PropEr papers and talks
- Tips: For the effective use of PropEr
- Tutorials: Showing the tool's PropEr use

Last edited on 2011-06-07.

A PropEr question

Why did you create PropEr?

PropEr progress four months later

IT HAS TAKEN ME A LONG TIME,
BUT I FINALLY FINISHED THE IMPLEMENTA-TION
GOOD JOB! THIS WILL DO AS A BASIS
NOW IT'S TIME TO START WORKING ON YOUR THESIS TOPIC
4 MONTHS OF WORK AND I HAVEN'T EVEN STARTED YET?
THAT'S RIGHT
JORGE CHAM © 2010
WWW.PHDCOMICS.COM

PropEr shrinking

```
41> c(simple_props).
{ok,simple_props}
42> proper:quickcheck(simple_props:prop_delete()).
.........................................!
Failed: After 42 test(s).
{12,[-36,-1,-2,7,19,-14,40,-6,-8,42,-8,12,12,-17,3]}

Shrinking ...(3 time(s))
{12,[12,12]}
false
```

PropEr integration with types

```
-type tree(T) :: 'leaf' | {'node',T,tree(T),tree(T)}.
```

```
%% A tree delete implementation
-spec delete(T, tree(T)) -> tree(T).
delete(X, leaf) ->
  leaf;
delete(X, {node,X,L,R}) ->
  join(L, R);
delete(X, {node,Y,L,R}) ->
  {node,Y,delete(X,L),delete(X,R)}.
```

```
join(leaf, T) -> T;
join({node,X,L,R}, T) ->
  {node,X,join(L,R),T}.
```

```
prop_delete() ->
  ?FORALL({X,L}, {integer(),tree(integer())},
          not lists:member(X, delete(X, L))).
```

What one would have to write in EQC

```
tree(G) ->
  ?SIZED(S, tree(S, G)).

tree(0, _) ->
  leaf;
tree(S, G) ->
  frequency([
    {1, tree(0, G)},
    {9, ?LAZY(
          ?LETSHRINK(
            [L,R],
            [tree(S div 2, G),tree(S div 2, G)],
            {node,G,L,R}
        ))}
  ]).
```

What one has to write in PropEr

This slide intentionally left blank

PropEr testing of specs

```
1> c(myspecs).
{ok,myspecs}
2> proper:check_spec({myspecs,divide,2}).
!
Failed: After 1 test(s).
An exception was raised: error:badarith.
Stacktrace: [{myspecs,divide,2}].
[0,0]

Shrinking (0 time(s))
[0,0]
false
      .... AFTER FIXING THE PROBLEMS ....
42> proper:check_specs(myspecs).
```

PropEr testing of stateful systems

- PropEr **`statem`** or **`fsm`** libraries
  - automatically generate test cases from the model and
  - execute them to test the real implementation against the model

- However, the test cases should be generated strictly *before* they are run
  - otherwise, they are not repeatable and we cannot shrink them

Thanks from the PropEr developers!