Password Cracking

Fun with Erlang Concurrency

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LANDMARKS OF NEW YORK
NEW YORK STOCK EXCHANGE
THIS CENTRAL MARKET PLACE FOR THE PURCHASE AND SALE OF SECURITIES WAS FOUNDED IN 1792 BY MERCHANTS WHO MET DAILY BENEATH A BUTTONWOOD TREE THAT GREW NEARBY. COMPLETED IN 1903 FROM DESIGNS BY GEORGE B. POST SCULPTORS OF PEDIMENT GROUP WERE J. Q. A. WARD AND PAUL W. BARTLETT
THE NEW YORK COMMUNITY TRUST
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was "mor-muney"?
ICANHASCHEEZBURGER.COM

Er-what?

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- What: Functional language, not Object- Oriented
- Who: Ericsson Computer Science Laboratory
- Where: erlang.org. This code: search “erlang_md5crack” on github.com

Why Erlang?

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- Concurrency

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- Hot-upgradable code

Erlang 101

Variables

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- They don't vary - really, never
- B = 1 is a statement of fact, not an assignment
- Mathematically B = B + 1 makes no sense, same in Erlang
- B = 2 is similarly illegal

```
1> B = 1.
1
2> B = 3 - 2.
1
3> B = 2.
** exception error: no match of right hand side value 2
4>
```

Data types

- Number (integer and float)

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- Atom (literal):
  - hello
  - kitty

Lists

- X = [1,2,3].
- Y = [an_atom,{tuple,tuple},"hello",9.45].
- [Z|Rest] = X.

```
4> X = [1,2,3].
[1,2,3]
5> [Z|Rest] = X.
[1,2,3]
6> Z.
1
7> Rest.
[2,3]
8>
```

Tuples

- {Term1,.....,TermN}
- Shape1 = {square,4}
- Shape2 = {circle,5}

String: syntactic sugar

- An array of integers with ASCII values
- Not a data type

```
25> S = [100,111,103].
"dog"
26> T = [100,111,103,999].
[100,111,103,999]
27> U = "dog".
"dog"
28> [V|_] = U.
"dog"
29> V.
100
```

Pattern Matching and Recursion

```
countdown(0) ->
    io:format("0~n");
countdown(N) ->
    io:format("~p~n",[N]),
    countdown(N-1).
```

```
6> misc:countdown(3).
3
2
1
0
ok
7>
```

Fun() with anonymous functions

```
1> Doubler = fun(N) -> 2*N end.
#Fun<erl_eval.6.13229925>
2> Doubler(2).
4
3> Doubler(15).
30
```

Processes

- Pid = spawn(Fun).

Processes

- Pid = spawn(Fun) :spawns new function referenced by Pid
- Pid ! Message :sends message to process

Processes

- Pid = spawn(Fun) :spawns function as a process referenced by Pid
- Pid ! Message :sends message to process
- receive...end :block used by process to receive messages

```
loop() ->
    receive
        {double,N} ->
            io:format("Double ~p is ~p~n",[N, N*2]),
            loop();
        {triple,N} ->
            io:format("Triple ~p is ~p~n",[N, N*3]),
            loop();
        close ->
            io:format("closing...~n");
        Other ->
            io:format("Don't know how to ~p~n",[Other]),
            loop()
end.
```

```
5> Pid = spawn(fun() -> misc:loop() end).
<0.44.0>
```

```
5> Pid = spawn(fun() -> misc:loop() end).
<0.44.0>
6> Pid ! {double,2}.
Double 2 is 4
{double,2}
7> Pid ! {triple,2}.
Triple 2 is 6
{triple,2}
```

```
5> Pid = spawn(fun() -> misc:loop() end).
<0.44.0>
6> Pid ! {double,2}.
Double 2 is 4
{double,2}
7> Pid ! {triple,2}.
Triple 2 is 6
{triple,2}
8> Pid ! say_fail.
Don't know how to say_fail
say_fail
9> Pid ! close.
closing...
close
```

Back to the Passwords

Don't Be Evil!

- For demonstration purposes only
- Not production-ready

Problem

- Simple, non-reversible password creation by MD5 algorithm

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- MD5.hexdigest("hi") = 49f68a5c8493ec2c0bf489821c21fc3b

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- MD5.hexdigest("hi") = 49f68a5c8493ec2c0bf489821c21fc3b
- How to determine plaintext when given hash?

Bruteforce Solution

- Check the MD5 hash of every possible string. When hashes match, password found.

Check all strings between “aa” and “zz”

```
irb(main):005:0> MD5.hexdigest("aa")
=> "4124bc0a9335c27f086f24ba207a4912"
irb(main):006:0> MD5.hexdigest("hh")
=> "5e36941b3d856737e81516acd45edc50"
irb(main):007:0> MD5.hexdigest("hi")
=> "49f68a5c8493ec2c0bf489821c21fc3b"
```

Exponential Time

- Length 1: 26 ^ 1 = 26 possiblities

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Exponential Time

- Length 1: 26 ^ 1 = 26 possiblities
- Length 2: 26 ^ 2 = 676
- Length 3: 26 ^ 3 = 17,576
- Length 6: 308,915,776
- Length 7: 8,031,810,176
- Length 8: 5.4 trillion +

Strategy: Divide & Conquer

- 3-letters, single process = search from ‘aaa’ to ‘zzz’

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- 3-letters, single process = search from ‘aaa’ to ‘zzz’
- 3-letters, 2 processes: ‘aaa’ to ‘mzz’, ‘naa’ to ‘zzz’

Strategy: Divide & Conquer

- 8 processes:

```
[{"aaa","dgm"},
 {"dgn","gmz"},
 {"gna","jtm"},
 {"jtn","mzz"},
{"naa","qgm"},
{"qgn","tmz"},
{"tna","wtm"},
{"wtn","zzz"}]
```

Find first letter for string length

- a = 0, z = 25
- aa = 26 (not [0],[0])
- aaa = 702

Find first letter for string length

- a = 0, z = 25
- aa = 26
- aaa = 702
- first(3) = 26^2 + 26^1
- recursively calc 26^n-1 until n = 0

Find first letter for string length

```
first_int(Len) when Len > 0 ->
    first_int(Len-1, 0).

first_int(0, Acc) ->
    Acc;
first_int(Len, Acc) ->
    first_int(Len - 1, Acc + round(math:pow(26, Len))).
```

Divide and Conquer II

- 3 letters, 3 processes:
  - 17576 / 3 = 5858.667 strings / proc
  - [{702, 6560},{6561,12419}, {12420,18277}]
  - [{"aaa","iri"},{"irj","rir"},{"ris","zzz"}]

Number to Char Array

- Use hexavigesimal math

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```
chr_array(I) ->
    chr_array(I, []).

chr_array(I, L) when I > 25 ->
    R = I rem 26,
    D = I div 26,
    chr_array(D - 1, [R+$a|L]);
chr_array(I, L) ->
    [I + $a|L].
```

- chr_array(703) = [97,97,98] = “aab”

Spawn N processes

```
decrypt(Crypted, Len, Processes) ->
    CharPartitions = partition_alphabet(Len, Processes),
    Server = self(),
    StartTime = now(),
    lists:foreach(fun({Min,Max}) ->
        spawn(fun() ->
            analyze(Server, Crypted, Min, Max, Len) end)
    end, CharPartitions),
loop(Processes, StartTime, notfound).
```

Client analyze function

```
analyze(Server, Crypted, Cur, Max, Len) ->
    case erlang:md5(Cur) of
        Crypted ->
            Server ! {found, Cur};
        _ ->
            analyze(Server, Crypted, next(Cur), Max, Len)
    end.
```

Client analyze function

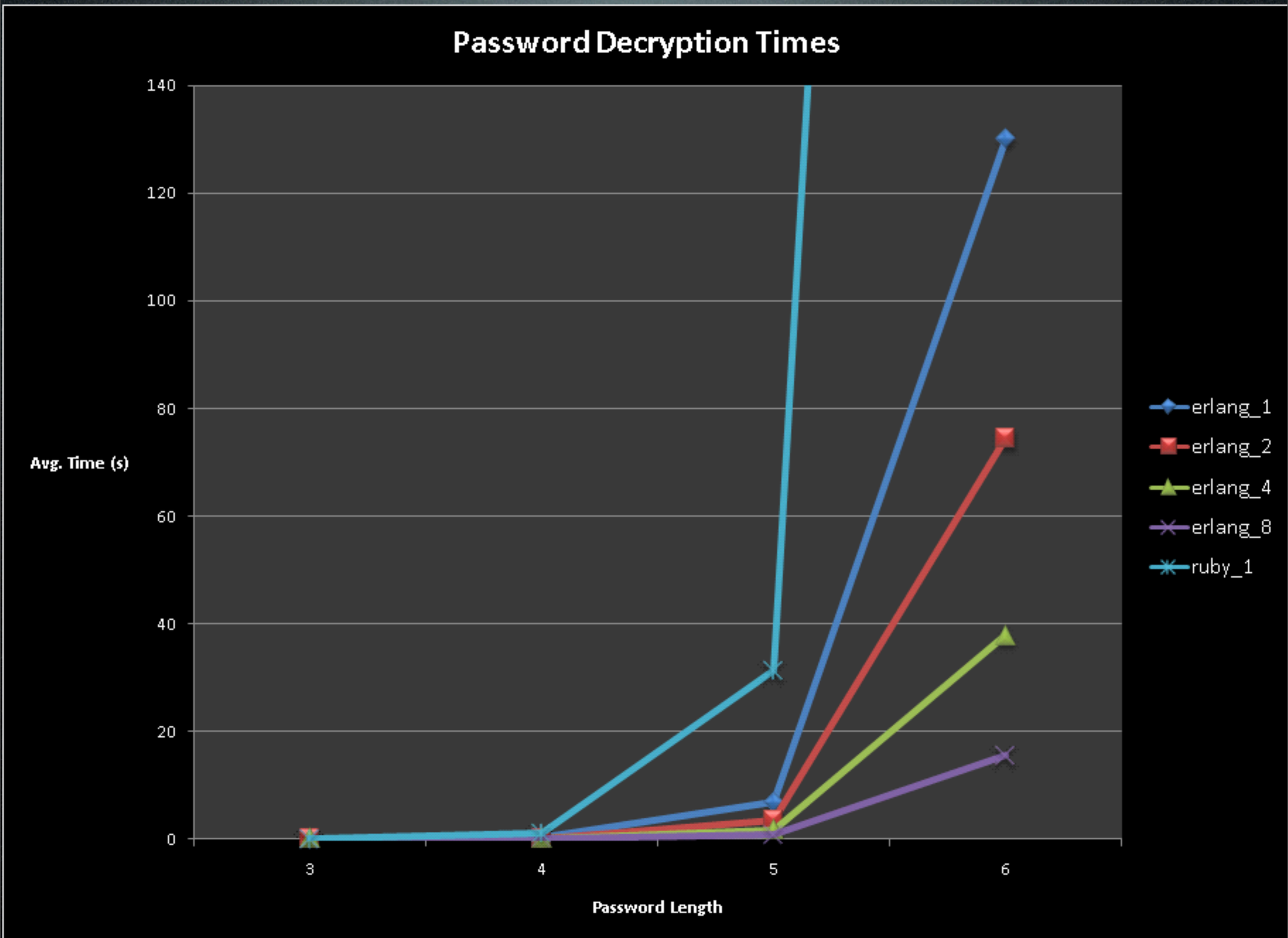
```
analyze(Server, Crypted, Max, Max, Len) ->
    case erlang:md5(Max) of
        Crypted ->
            Server ! {found, Max};
        _ ->
            Server ! notfound
    end;
analyze(Server, Crypted, Cur, Max, Len) ->
    case erlang:md5(Cur) of
        Crypted ->
            Server ! {found, Cur};
        _ ->
            analyze(Server, Crypted, next(Cur), Max, Len)
    end.
```

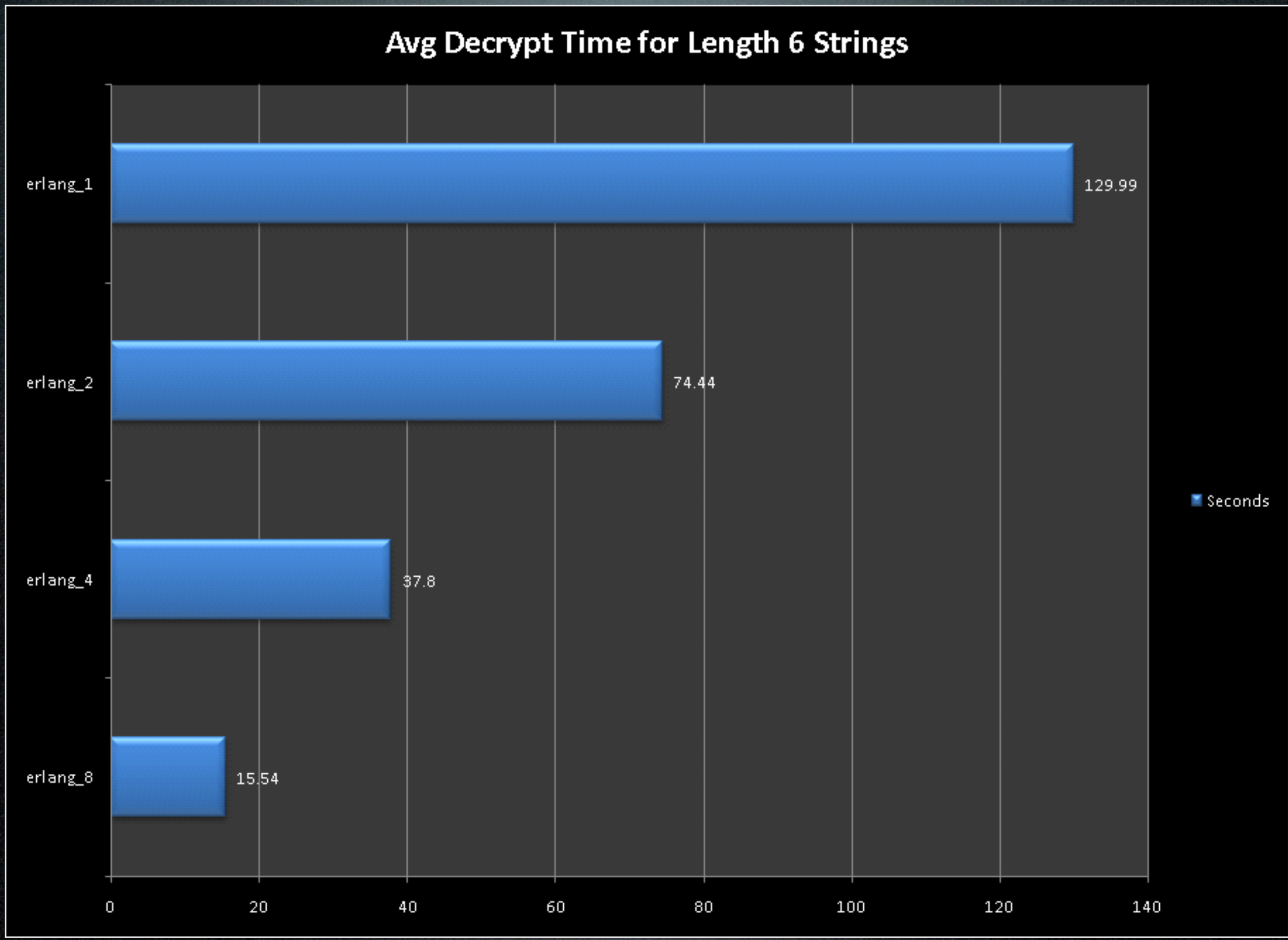
Server function

```
loop(0, _Start, Ret) ->
    Ret;
loop(Processes, Start, Ret) ->
    receive
        {found, Password} ->
            Elapsed = timer:now_diff(now(), Start) / 1000 / 1000,
            loop(Processes-1, Start, {found,Password,Elapsed});
    notfound ->
        io:format("Processes remaining: ~p~n",[Processes]),
        loop(Processes-1, Start, Ret)
end.
```

Testing

- Amazon EC2, High-CPU Extra Large Instance
- 8 cores, 7 GB RAM
- Fedora Core 6
- Erlang R12B-4, Ruby 1.8.6


Password Decryption Times
140
120
100
80
60
40
20
0
Avg. Time (s)
3
4
5
6
Password Length
erlang_1
erlang_2
erlang_4
erlang_8
ruby_1


Avg Decrypt Time for Length 6 Strings
erlang_1
129.99
erlang_2
74.44
erlang_4
37.8
erlang_8
15.54
Seconds
0
20
40
60
80
100
120
140

Final Thoughts

- Learn: pragmatic programmer at pragprog.com
- Look into phofs:mapreduce
- Disco: Python functions, Erlang engine at http://discoproject.org/