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Erlang – functional programming in a concurrent world

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Erlang

Concurrent Oriented Programming

- processes have state
- communicate using message passing
- access and location transparent
- asynchronous

Functional programming

- evaluation of expressions
- recursion
- data structures are immutable

History

Developed at Ericsson in late eighties, early nineties.

Targeting robust applications in the telecom world.

Survived despite “everything must be Java”

Growing interest from outside Ericsson.

Today

Why Erlang?

- concurrency built-in
- multicore performance
- simple to implement fault tolerance
- scales well in distributed systems

Erlang

- the functional subset
- concurrency
- distribution
- failure detection

Data structures

- ***Literals***
  - atoms: foo, bar, ...
  - numbers: 123, 1.23 ..
  - bool: true, false

- ***Compound structures***
  - tuples: {foo, 12, {bar, zot}}
  - lists: [], [1,2,foo,bar]

Variables

- lexically scoped
- implicit scoping – the procedure definition
- untyped – assigned a value when introduced
- syntax: X, Foo, BarZot, _anything

Assignment – Pattern matching

Assignment of values to variables is done by ***pattern matching***:

```
<Pattern> = <Expression>
```

A ***pattern*** can be a single variable:

```
Foo = 5
Bar = {foo, zot, 42}
```

or a compound pattern

```
{A, B} = {4, 5}
{A, {B, C}} = {41, {foo, bar}}
{A, {B, A}} = {41, {foo, 41}}
```

Pattern matching

Pattern matching is used to extract elements from a data structure.

```
{person, Name, Age} = find_person(Id, Employes),
```

Pattern matching

Pattern matching can fail:

```
{person, Name, Age} = {dog, pluto}
```

No circular structures

You can not construct circular data structures in Erlang.

(a structure in which the last element is a pointer to the first)

Pros – makes the implementation easier.

Cons – Someone might like/need circular structures.

Definitions

```
area(X, Y) -> X * Y.
```

if statement

```
fac(N) ->
      if
         N == 0 -> 1;
         N > 0 -> N*fac(N-1)
      end.
```

case statement

```
sum(L) ->
      case L of
         [] ->
            0;
         [H|T] ->
            H + sum(T)
      end.
```

case statement

```
member(X,L) ->
      case L of
         [] ->
            no;
         [X|_] ->
            yes;
         [_|T] ->
            member(X, T)
      end.
```

Higher order

```
F = fun(X) -> X + 1 end.
F(5)
```

Higher order

```
map(Fun, List) ->
        case List of
            [] ->
                [];
            [H|T] ->
                [Fun(H) | map(Fun, T)]
        end.
```

Modules

```
-module(lst).
-export([reverse/1]).

reverse(L) ->
       reverse(L,[]).

reverse(L, A) ->
       case L of
          [] ->
             A;
          [H|T] ->
             reverse(T,[H|A])
       end.
```

Modules

```
-module(test).
-export([palindrome/1]).

palindrome(X) ->
      case lst:reverse(X) of
        X ->
            yes;
        _ ->
            no
      end.
```

Concurrency

Concurrency is explicitly controlled by creation (spawning) of processes.

A process is when created, given a function to evaluate.

no one cares about the result

Sending and receiving messages is the only way to communicate with a process.

no shared state (. . .well, almost)

Spawn a process

```
-module(account)

start(Balance) ->
       spawn(fun() -> server(Balance) end).

server(Balance) ->
:
:
:
```

Receiving a message

```
server(Balance) ->
        receive
          {deposit, X} ->
               server(Balance+X);
          {withdraw, X} ->
               server(Balance-X);
          quit ->
               ok
        end.
```

Sending a message

```
:
Account = account:start(40),
Account ! {deposit, 100},
Account ! {withdraw, 50},
:
```

RPC-like communication

```
server(Balance) ->
      receive
      :
      {check, Client} ->
            Client ! {saldo, Balance},
      server(Balance);
      :
      end.
```

RPC-like communication

```
friday(Account) ->
      Account ! {check, self()},
      receive
         {saldo, Balance} ->
             if
                Balance > 100 ->
                    party(Account);
                true ->
                     work(Account)
             end
      end.
```

Implicit deferral

A process will have an ordered sequence of received messages.

The first message that matches one of several program defined patterns will be delivered.

Pros and cons:

- one can select which messages to handle first
- risk of forgetting messages that are left in a growing queue

Registration

A node registers associate names to process identifiers.

```
register(alarm_process, Pid)
```

Knowing the registered name of a process you can look-up the process identifier.

The register is a shared data structure!

Registration

Erlang nodes (an Erlang virtual machine) can be connected in a group .

Each node has a unique name.

Processes in one node can send messages to and receive messages from processes in other nodes using the same language constructs

Starting a node

```
moon> erl -sname gold -setcookie xxxx
:
:
(gold@moon)>
```

Failure detection

- a process can monitor another process
- if the process dies a messages is placed in the message queue
- the message will indicate if the termination was normal or abnormal or ..... if the communication was lost

Monitor

```
Ref = erlang:monitor(process, Account),
Account ! {check, self()},

receive
   {saldo, Balance} ->
      :
   {’DOWN’, Ref, process, Account, Reason}->
      :
   end
```

Atomic termination

- A process can link to another process, if the process dies with an exception the linked process will die with the same exception.
- Processes that depend on each other are often linked together, if one dies they all die.

Linking

```
P = spawn_link(fun()-> server(Balance) end),
do_something(P),
```

Summary

- functional programming
- processes
- message passing
- distribution
- monitor/linking