CPL - Erlang

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25 October 2013

Outline

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What is Erlang?

- programming language + runtime system

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- functional (like Racket )

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Runtime system:

- garbage collector (like Java )

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- **inherently concurrent programs:**
  internal support for processes
- **distributed programs** on different machines
- **fault-tolerant systems:**
  several mechanisms to recover faults without a system crash
- **non-stop applications:**
  ability to load code at runtime

Why **NOT** using Erlang?

- **Poor support for frontends**

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- **Not as supported as other languages** (unlike Java )

Why **NOT** using Erlang?

- **Poor support for frontends**
- **Not as supported as other languages** (unlike Java )
- **Not known / understood as other languages** (unlike Java  or C) (like Racket )

Who uses Erlang?

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Outline

Functional code

```
-module(app).

-export([func/1]).

func( Num )->
    Local_Var = 2 * Num,
    Avg = average([Num, Local_Var]),
    Sqr_Avg = math:sqrt(Avg),
    io:format("Result ~p. ~n",[Sqr_Avg]),
    ok.

average( L ) ->
    lists:foldr(fun(El, Acc)-> El + Acc end , 0, L).
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Functional code

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module definition

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EVERYTHING ends with a dot "."

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list of exported functions

Functional code

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-module(app).

-export( [ func/1 ] ).
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list of exported functions

lists are between square brackets “[ ] ”

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variable, single assignment

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mind the difference!!

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Module name – colon ":" – function name

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supports higher-order functions

(like Scala  , Haskell 

, Racket 
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anonymous function (like Scala  , Racket )

Erlang datatypes (selection of)

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- Lists: `[ Head | Tail ]`. `[]` denotes an empty list.

Dynamic typing

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- This is a valid erlang program (will **fail** at runtime)

```
add( X, Y ) ->
    X + Y
end.
...
add( 5, "marco" ).
```

Compiling and running Erlang code

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- run commands within the console
- `c(filename).` compiles from the console

Useful links

- Erlang API: http://www.erlang.org/doc/man_index.html
- Part I of *Concurrent programming in Erlang*, by J. Armstrong, R. Virding, C. Wikström and M. Williams: http://www.erlang.org/download/erlang-book-part1.pdf
- http://www.erlang.org/static/getting_started_quickly.html
- http://www.erlang.org/doc/getting_started/users_guide.html
- http://learnyousomeerlang.com/

Coding time

Coding time

`length/1`,
dynamic type error with length/1, atom_to_list BIF,
`filter/2`,
anonymous functions, guards in functions,
`tailFilter/2`

Outline

The Actor model

- everything is an actor

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- messages are the means of communication (asynchronous)
- actors have mailboxes where messages are queued
- actors send and `receive` messages (only 2 primitives)

Actors vs Threads

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- (generally) context switched by the runtime
- message passing (asynchronous)
- no race conditons: no locking
- can deadlock

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- (generally) context switched by the runtime
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Threads

- (generally) context switched by the OS
- shared memory (sync/async)
- race conditions: needs locking
- can deadlock

Erlang's concurrency model, informally

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Actor model:

- actors are *lightweight processes*, not OS processes, not threads
- 309 words of memory when spawned (very small!)
- fixed point context switches (optimal concurrency)
- processes have mailboxes
- send and **`receive`** are part of syntax, not in a library as Scala  , Akka (for Java ), actor framework (for .Net)

Receiving messages in Erlang

```
receive
    mess ->
        ok;
    {tuple, Number} ->
        io:format("Received ~p",[Number])
    after
        10000 ->
            ok
end.
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separate by ";"

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last clause ends with NOTHING

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timeout clause

The receive loop

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server( NumMess )->
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            server( Number ) + 1
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- a receive loop is a recursive **receive** inside a function
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server( NumMess )->
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        mess ->
            server( NumMess + 1 ),this one is ok
        {tuple, Number} ->
            server( Number ) + 1
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this one is NOT

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State of the function (unlike Java  , C)

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- PIDs can be registered to local names with **`register`**`/2` (good for servers and for failing-respawning processes)

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- PIDs can be registered to local names with **`register`**`/2` (good for servers and for failing-respawning processes)
- local names are fetch with **`registered`**`/0`

Coding time

Coding time

receive messages, send messages, timeout

`spawn/3, register/2, unregister/1`

receive loop

Outline

The “Let it crash” philosophy

- expect failure
- deal with it

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Failures:

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Failures:

- in the same function: *exceptions, errors and exits*.

  Handled with `try / catch`, like in Java  and Scala 
- in another process
  Handled as messages by *monitor/2* and *link/1*

Exceptions – throwing

Three types:

```
throw(Exception).
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erlang:error(Reason).
exit(Reason).
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Exceptions – catching

```
throws(F) ->
    try F() of
        _ -> ok
    catch
        Throw -> {throw, caught, Throw};
        error:Error -> {error, caught, Error};
        exit:Exit -> {exit, caught, Exit}
    end.
```

Monitoring

- *Unidirectional*
- receive message when process dies:
  `{ 'DOWN', MonitorReference, process, Pid, Reason}`

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- receive message when process dies:
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```
Pid = spawn( function ),
Ref = monitor(process, Pid).
 ... % or
{ Pid , Ref } = spawn_monitor( function ).
... %remove with
demonitor( Ref ).
```

Linking

- *Bidirectional*
- receive message when *either* process dies:
  `{ 'EXIT', Pid, Reason}`
- only active after `process_flag(trap_exit, true)`

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```
Pid = spawn( function ).
link( Pid ).
 ... % or
Pid = spawn_link( function ).
... %remove with
unlink( Pid ).
```

Coding time

Coding time

try/catch

`spawn_link/3, link/1, monitor/2`

Outline

What is distribution?

- processes on different Erlang nodes

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- different Erlang nodes on different machines

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- processes on different Erlang nodes
- different Erlang nodes on different machines
- some applications are *inherently* distributed

Erlang Nodes

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- an Erlang node is an executing Erlang system
- a node is given a name `erl -name asd`
- the BIF **`node`**`/0` returns the full name
- the BIFs **`spawn`**`/1-4`, `monitor/2`, **`link`**`/1`, **`register`**`/2` all work also with node names

Nodes

- connect with `net_kernel:connect_node( NodeName )`

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- use `-hidden` to prevent communications

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distributed communication

Conclusion

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- concurrent (also parallel and distributed)
- functional
- fail-resistant

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Erlang is:

- concurrent (also parallel and distributed)
- functional
- fail-resistant

- good for backend software
- good for long-lived applications

Homework and lab exercises

Find the homework exercise in Toledo.
Lab sessions:

- November 5, 2013 from 1:30 PM to 4:00 PM, Location: 200A.00.124
- November 8, 2013 from 10:35 AM to 1:05 PM, Location: 200A.SOL_Z