PSC 2021/22 (375AA, 9CFU)

Principles for Software Composition

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16 - Erlang

Erlang

concurrency oriented programming

Erlang: a concurrent programming language

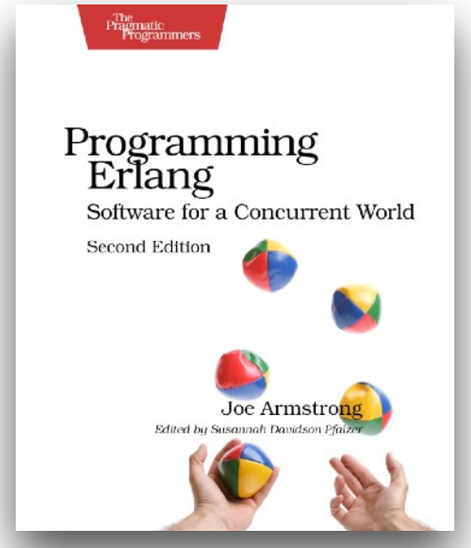
http://www.erlang.org/

Erlang: origins

named after Danish mathematician A. K. Erlang

1986: first experimentation at Ericsson, Sweden
1989: internal use only
1990: sold as a product
1998: open source

Joe Armstrong, “Programming Erlang”, ch.1-5, 11-12



Features

declarative (functional, Prolog) programming

arbitrary size integers, tuples, lists, functions, higher-order

atoms everywhere

dynamically typed

open source

unfamiliar syntax

variables are assigned only once

left-to-right evaluation, no pointers, no object-orientation

Features: concurrency

concurrent and distributed programming

asynchronous message passing
(no locks, no mutexes)

fault tolerance

hot swapping code

erlang processes are cheap

automatic memory allocation and garbage collection

can handle large telecom applications

Erl

Erlang: erl

erl is the Erlang VM emulator

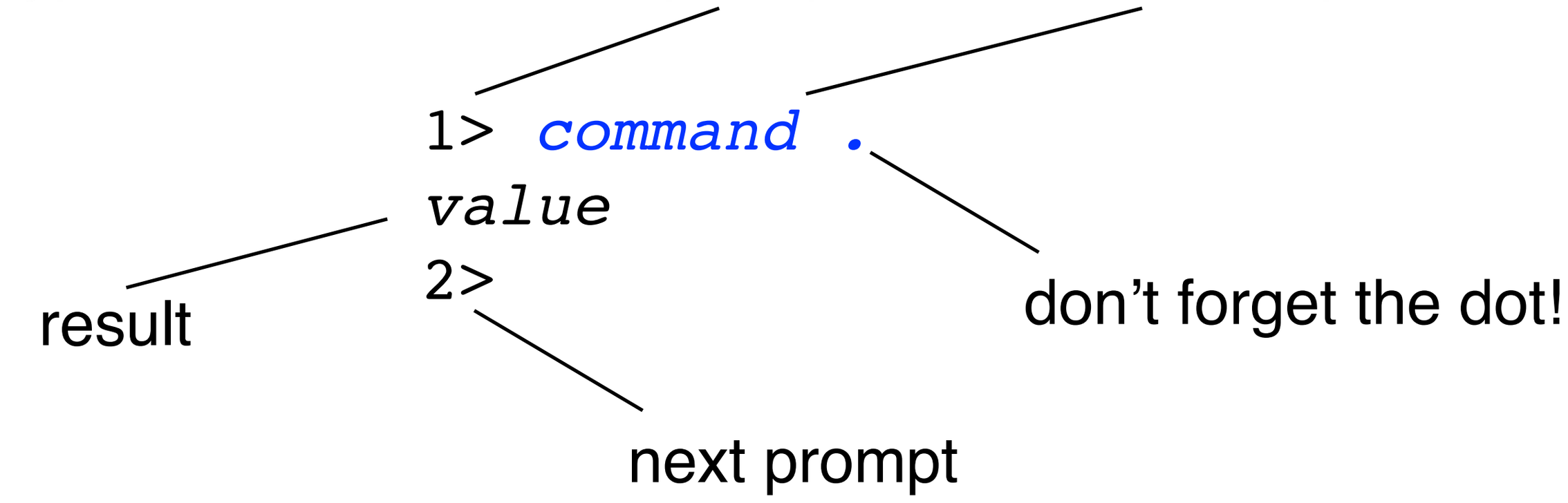
interactive shell or interpreter, executing read-eval-print loop

programmers enter expressions / declarations one at a time

they are compiled / executed

erl expressions

typical interaction:



`halt().` to exit the emulator

Erlang modules

functions are organised in modules

one module for source file

filename is module name with suffix `.erl`

a comment — arity — declarations end with a dot

```
% filename hello.erl
-module(hello).
-export([hello/0]).

hello() -> io:format("Hello, world!~n").
```

function def

module name — separator — function name — argument

erl: module loading

compile and load the module

```
1> c(hello) .
{ok,hello}
2> hello:hello() .
Hello, world!
ok
3>
```

invoke the function

return value

next prompt

if you edit `hello.erl` and do `c(hello)` again
the new version of the module replaces the old one

Erlang basics

Function definition

separates function clauses with ;
last clause ends with .

variables start with upper-case letters X Head Tail
variables are local to function clauses

function definitions cannot be nested
non-exported functions are local to the module

pattern matching allowed

guards allowed (keyword `when`)

type-checking is done at runtime

Atoms, tuples, lists

numbers: arbitrary size integers, floating point values
(cannot start with .)

atoms: start with lower-case character
(can be single-quoted if needed, don't use camelCase)

```
true  ok  hello_world.  'this is an atom'
```

tuples: main data constructor
tagged tuples: the first element of the tuple is an atom
we can use pattern matching

```
{}  {movie,"Matrix"}   {movie,Title}
```

lists: can contain elements of any type
we can use pattern matching

```
[]  [1,2,ok]  [H|T]  [X,Y,Z]  [X,Y,Z| Tail]
```

Funs

funs: anonymous functions (lambda expressions)
can have several arguments and clauses

```
fun () -> 42 end
```

```
fun (X) -> X+1 end
```

```
fun (X,Y) -> {X, fun (Z) -> Z+Y end} end
```

```
fun (F,X) -> F(X) end
```

Type test & conversion

```
is_integer(X)
is_float(X)
is_number(X)
is_atom(X)
is_tuple(X)
is_list(X)
is_function(X)
is_pid(X)
…
```

```
atom_to_list(A)
list_to_atom(L)
tuple_to_list(T)
list_to_tuple(L)
…
```

Erlang concurrency

Processes

every Erlang code is executed by a process

processes are implemented by the VM (not by OS threads)

multitasking is preemptive (VM switching and scheduling)

processes need very little memory

switching between processes is very fast

the VM can handle a large number of processes

on multiprocessor/multicore machines, processes can be scheduled to run in parallel on separate CPUs/cores using multiple schedulers

different processes may be reading the same program code at the same time (no variable updates!)

Pids

each process has a process identifier

```
Pid = self()
```

new Erlang processes can be spawned to run functions

```
Pid = spawn(module,function,arguments)
```

```
Pid = spawn(fun () -> … end)
```

```
Pid = spawn(fun f/0)
```

```
Pid = spawn(fun m:f/0)
```

the spawn operation returns immediately
(the return value is the pid of the process)

children pids are available to parent process,
not vice versa (unless passed)

Communication

Messages can be sent to pids

```
Pid ! message
```

called bang

Processes can wait to receive (and select) some message

```
receive … end
```

Message passing

`receive … end`

Pid

Pid `!` *message*

Message passing

messages are sent asynchronously
(the sender continues immediately)

any value can be sent as a message

each process has a message queue (mailbox)
no size limit, messages are kept until extracted

a message is received when it is extracted from the mailbox

messages are ordered from oldest to newest in the mailbox

the message that is extracted is not necessarily the oldest
(pattern matching can be used, if there is no match
the receiver suspends and keeps waiting)

Reply

To reply a message, its sender must be known

its pid can be inserted in the message

syntax for tuples

```
Pid ! { Mypid , message }
```

now the receiver *Pid* can reply to *Mypid*

erl session

bruni — beam.smp -- -root /usr/local/Cellar/erlang/21.2.2/lib/erlang -progname erl -- -home ~ -- ▸ erl_child_setup — 106×24

```
Last login: Fri Apr 17 11:42:07 on ttys001
host-131-114-219-127:~ bruni$ erl
Erlang/OTP 21 [erts-10.2.1] [source] [64-bit] [smp:12:12] [ds:12:12:10] [async-threads:1] [hipe] [dtrace]

Eshell V10.2.1  (abort with ^G)
1>
```