Erlang
Language Introduction
What is Erlang?

• Language developed at Ericsson
• Core language is a simple dynamically-typed functional programming language
• Concurrent (light-weight processes belong to language, not OS)
• “Share nothing” process semantics
• Pure asynchronous message passing
• Transparent distribution of processes across machines
• Mechanisms for in-service code upgrade
• Large set of libraries (OTP)

from: http://portal.acm.org/citation.cfm?id=1238844.1238850
History of Erlang

• (mid-80s) Ericsson (Swedish telecom company) set out to find the best language for building the next generation of telecom systems

• Requirements
  - Handling a very large number of concurrent activities
  - Systems distributed over several computers
  - Actions to be performed at a certain point of time or within certain time
  - Very large software systems
  - Complex functionality such as feature interaction
  - Continuous operation over several years
    - Software maintenance (reconfiguration, etc.) without stopping the system
    - Stringent quality and reliability requirements
    - Fault tolerance both to hardware failures and software errors

from: http://portal.acm.org/citation.cfm?id=1238844.1238850
History of Erlang cont’d

• Initially Smalltalk was considered. Method calls in Smalltalk are “message sends.” Message passing figures prominently in Erlang’s design.

• Soon after, they discovered that the rules for how a telecom system should work could be elegantly expressed in the logic language Prolog. The first Erlang interpreters were written in Prolog and the syntax retains the flavor of Prolog.
History of Erlang cont’d

- Prolog is a **logic language** - a program consists of facts and queries over those facts are evaluated

```
mother_child(trude, sally).
father_child(tom, sally).
father_child(tom, erica).
father_child(mike, tom).
sibling(X, Y) :- parent_child(Z, X),
                   parent_child(Z, Y).
parent_child(X, Y) :- father_child(X, Y).
parent_child(X, Y) :- mother_child(X, Y).
```

- It turns out that the logic features of Prolog were deemed unnecessary for telecom systems so they were removed from Erlang (leaving a functional language)

```
http://en.wikipedia.org/wiki/Prolog
```

```
parent_child(X, Y) :- father_child(X, Y).
parent_child(X, Y) :- mother_child(X, Y).
?- sibling(sally, erica).
Yes
```
History of Erlang cont’d

- Other modifications from Prolog were the addition of concurrency and message passing. The syntax diverged over time.

- Erlang continued to evolve “organically”, growing from 2 to “hundreds” of developers between 1989 and 1997.


- Banned within some groups at Ericsson in 1998, released as open source.
Real-World Erlang

- CouchDB - document store “NoSQL” database
- Facebook Chat
- RabbitMQ - owned by VMWare, message queue server
- ejabberd - XMPP (jabber chat) server
- Amazon SimpleDB
- GitHub
- Wings3d - open source 3d modeling tool
- ... and more: http://stackoverflow.com/questions/690875/real-world-applications-of-erlang
Why Erlang?

• Functional (like OCaml, Scheme, Haskell)
  • Program by evaluating functions to produce results, not by mutation of program state
  • A good match for concurrent programming since concurrent access to shared state (and the required mutual exclusion) are the source of many bugs (races, atomicity violations, deadlocks)
Why Erlang? cont’d

• Transparent distribution of processes across machines
• Efficient implementation of processes, message passing
• Robust error handling support
• Runtime updates
Installing Erlang

- Available on linuxlab.cs.umd.edu (R14B) - access using class account (see grades server for login info)
- Windows: http://erlang.org/download.html
- Mac: need to build from source
- Web REPL: http://www.tryerlang.org/
Erlang Resources

• Getting Started with Erlang ([http://www.erlang.org/doc/getting_started/users_guide.html](http://www.erlang.org/doc/getting_started/users_guide.html))

• Erlang Documentation ([http://www.erlang.org/doc/](http://www.erlang.org/doc/))

• “learn you some Erlang for a great good” ([http://learnyousomeerlang.com](http://learnyousomeerlang.com))


• Erlang for Concurrent Programming (ACM Queue) ([http://queue.acm.org/detail.cfm?id=1454463](http://queue.acm.org/detail.cfm?id=1454463))

• Books:
  • Programming Erlang: Software for a Concurrent World (Armstrong)
  • Erlang Programming (Cesarino, Thompson)
Sequential Erlang
Erlang REPL

- Read-Eval-Print-Loop - allows immediate execution of Erlang code
- execute "erl" from the shell
- type "q()." to exit the REPL

```erl
> io:format("hello "),
  io:format("world\n").
```

Comma (,)

separates terms within an expression

Period (.) ends an expression
Erlang Numerics

1> 42.
2> $A.
3> $\n.
4> 2#101.
5> 16#1f.
6> 2.3.
7> 2.3e3.
8> 2.3e-3.

http://www.erlang.org/doc/reference_manual/data_types.html#id63103

- ASCII code for character
- 101 interpreted as binary
- 1F interpreted in base-16
- scientific notation
Erlang Arithmetic

1> +2.3.
  2.3
2> -2.3.
  -2.3
3> 12+2.3.
  14.3
4> 12-4*3.
  0
5> 10/3.
  3.3333333333333335
6> 10 div 3.
  3
7> 10 rem 3.
  1
8> 2#11001 band 2#10011 == 2#10000 bor 2#00001.
  true

unary operators

integer division/modulus

bitwise operators
Atoms

> hello.
> phone_number.
> 'Monday'.
> 'phone number'.
> true.
> false.
> ok.

- Atoms are extremely useful - uses include places where you might use enumerations (in C) or internal string constants (e.g. hash table keys in Java)

http://www.erlang.org/doc/reference_manual/data_types.html#id61072
Lists

[1, two, 3]

Heterogeneous

[1 | [two, 3] ]

Head

Tail

[1 | [two | [3 | [[]] ] ] ]

[1 | [two | [3 | [[]] ] ] ]
Strings

strings are lists of numbers

list operations apply to strings

can apply tools from lists and string modules

http://www.erlang.org/doc/man/string.html
http://www.erlang.org/doc/man/lists.html
Variable Binding / Pattern Matching

> X = 10.
10
> Y = hello.
hello
> X.
10
> Y.
hello
> X = 20.
** exception error: no match of right hand side value 20
> X = 10.
10
> 10 = 10.
10
> X = X + 1.
** exception error: no match of right hand side value 11

Erlang does not provide mutable variables!
Pattern Matching

> [First | Rest] = [1, two, 3].
[1, two, 3]
> First.
1
> Rest.
[two, 3]

> [A | _] = [1, two, 3].
[1, two, 3]
> [First, two, Q, _] = [1, two, 3, hello].
[1, two, 3, hello]
> Q.
3

Underscore means \textit{match anything}, don't create a binding.

Patterns can contain a mix of bound variables, unbound variables, literals, and underscores.
Tuples

• use lists for cases where length may vary and/or it makes sense to iterate through the data

• use tuples for data where each position has a distinct meaning

> {course, 433, enrollment, 30}.
> {course, 433, enrollment, 30}.

> R = {course, 433, enrollment, 30}.
> R.
> {course, 433, enrollment, 30}.

> {_, CourseNum, _, _} = {course, 433, enrollment, 30}.
> CourseNum.
> 433
Modules

- Erlang modules are placed in .erl files.

```erlang
-module(foo).
-export([somefun/0, otherfun/1]).
-import(io, [format/1]).
somefun() -> format("testing...
").
otherfun(X) -> X.
```

- same as file name (minus .erl)
- exported functions (name/arity)
- source module
- imported functions (name/arity)

no need to write "io:" due to import
Compilation

shell$ erlc file.erl

-or-

(erlang shell)
> c(file).
{ok,file}

produces file.beam for the erlang virtual machine

run compiled erlang code from commandline

erl file.beam -noshell -s file entry_func -s init stop

compiled file module function to call then stop
Functions

fun name args function body

area_circle(Radius) ->
   Pi = 3.14,
   RSquared = Radius * Radius,
   Pi * RSquared.

area({circle, Radius}) -> 3.14*Radius*Radius;
area({square, Side})   -> Side * Side;
area({rect, Length, Width}) -> Length * Width.
Recursive Functions

\[
\text{list\_sum}([],) \rightarrow 0; \\
\text{list\_sum}([\text{Head} \mid \text{Rest}]) \rightarrow \text{Head} + \text{list\_sum}(\text{Rest}).
\]

\[
\text{my\_map}(F, [],) \rightarrow []; \\
\text{my\_map}(F, [\text{Head} \mid \text{Rest}]) \rightarrow [F(\text{Head}) \mid \text{my\_map}(F, \text{Rest})].
\]
Anonymous Functions

> fun(X) -> X*X end.
#Fun<erl_eval.6.13229925>

> lists:map(fun(X) -> X*X end, [1,2,3,4,5]).
[1,4,9,16,25]

> lists:filter(fun(X) -> X rem 2 == 1 end, [1,2,3,4,5]).
[1,3,5]
Conditions

if
    X > 5 -> "greater";
    X < 5 -> "less";
    true -> "other"
end.

case X of
    king -> 13;
    queen -> 12;
    _ -> unknown
end.
List Comprehensions

\[
[X \ast X | | X <- [1,2,3,4]]
\]

\[
[{X,Y} | | X <- [1,2,3,4],
    Y <- [1,2,3,4]]
\]

\[
[{X,Y} | | X <- [1,2,3,4],
    Y <- [1,2,3,4],
    X>Y ]
\]
Error Handling

- "Fail-fast" philosophy - don’t handle every error, let the process fail (this will make more sense once we discuss multi-process servers)

```erlang
> throw(some_error_value).
** exception throw: some_error_value
> erlang:error(bad_arith).
** exception error: bad_arith
> erlang:exit(failure).
** exception exit: failure
```
Error Handling cont’d

> catch throw(some_error_value).
some_error_value

> catch 25.
25

try Expr()
catch
    Throw -> {caught_throw, Throw};
    exit:Exit -> {caught_exit, Exit};
    error:Error -> {caught_error, Error}
end