Introduction to Erlang
A Language For Message-Passing Concurrency

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Erlang? Isn't This Module About C?

- Erlang has a fairly simple and flexible syntax for message passing
- Trivial to write very scalable Erlang programs
- Erlang techniques are applicable elsewhere

Syntax In a Nutshell

Very Prolog-like:

- Variables start with upper case.
- Atoms start with lower case.
- Commas separate sequential statements
- Semicolon separates 'choice' statements
- Full stop as a terminator

Syntax In a Nutshell II

- Functions defined with arrow (-¿)
- Function-like syntax use for all control structures (if, case, etc)
- Last line is the return value (no explicit return)

Basic Principles

- Single Assignment
- Pattern Matching
- Small Processes
- Message Passing

Single Assignment

- Variables can only have one value
- Similar to Prolog

```
$ erl
1> A = 1.
1
2> A = 2.
** exception error: no match of right hand side value 2
```

Pattern Matching

- Anonymous Variable _ matches anything.
- Constants match themselves.
- Variables are instantiated.

```
-module(calc).
-export([evaluate/3]).

evaluate(add,A,B) ->
  A + B
;
evaluate(subtract,A,B) ->
  A - B.
```

Process Creation

- `spawn()` creates new Erlang processes
- Erlang processes are much cheaper than system processes
- Can be created on remote nodes

```
Pid = spawn(Node, Module, Function, Args).
```

Message Passing

- Send message to process
- Asynchronous
- Can send anything, even process IDs.

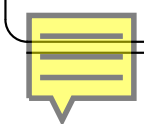
```
Pid ! Message.
```

Message Passing II

- Message passing is only useful if you can receive them
- Receive uses pattern matching

```
receive
    {ping, {Sender,Sent}} ->
        Sender ! {ack, {Sent, now()}}
    ;
    Error ->
        io:format("Invalid Message received
            ~w~n", [Error])
end.

Responder ! {ping, {self(),now()}},
    receive
        {ack, {Sent, Received} ->
            logRoundTrip(Sent, Received}
    end
```



Erlang Data Structures

- Tuples
- Lists

Tuples

- Fixed number of elements
- Can contain anything, including other tuples.
- Like C structures, but elements are anonymous
- Built in functions allow accessing

```
A = {1, 2, {elephant, B}, 12.5, "aardvark.",
     Pid}.
```

Lists

- Non-fixed number of elements
- Good for recursion
- Used to implement strings
- Can be converted to tuples

```
1> A = [1,2,3].
[1,2,3]
2> B = [0|A].
[0,1,2,3]
3> C = B ++ [4].
[0,1,2,3,4]
```

The Bit Syntax

- Converts between Erlang types and binary objects
- Great for network code
- Works with pattern matching

```
1> A = <<1,2,3,4,5,6>>.
<<1,2,3,4,5,6>>
2><<B:16/big,C:32/little>> = A.
<<1,2,3,4,5,6>>
3> B.
258
4> C.
100992003
```

A Note on Tail-Recursion

- Tail recursion is a very common idiom in Erlang
- Potentially infinite recursion is allowed, which needs an infinite stack
- This is solved by re-using the stack frame of a function that returns the result of another function

The Fibonacci Sequence

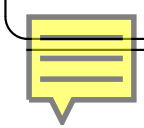
```
-module(fib).
-export([fib/1]).

fib(0) -> 1
;
fib(1) -> 1
;
fib(N) -> fib(N) + fib(N-2).
```

Quicksort

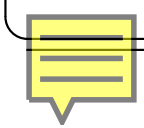
```
-module(qs).
-export([qs/1]).

qs([]) -> []
;
qs([X]) -> [X]
;
qs(List) ->
    [Pivot|Sublist] = List,
    {Less, Greater} =
        partition(Sublist, Pivot,[],[]),
    qs(Less) ++ [Pivot] ++ qs(Greater).
```



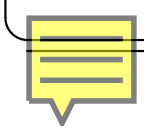
Quicksort Partition Function

```
partition([],_,Less, Greater) -> {Less, Greater}
;
partition([X|List],Pivot, Less, Greater) ->
    if
        X > Pivot ->
            partition(List, Pivot, Less, [X|
                Greater])
        ;
        true ->
            partition(List, Pivot, [X|Less],
                Greater)
    end.
```



Parallel Quicksort

```
pqs([],Parent,Tag) -> Parent ! {Tag,[]}
;
pqs([X],Parent,Tag) -> Parent ! {Tag,[X]}
;
pqs(List, Parent, Tag) ->
    [Pivot|Sublist] = List,
    {Less, Greater} = partition(Sublist, Pivot,[]
        ,[]),
    spawn(pqs,pqs,[Less,self(), less]),
    spawn(pqs,pqs,[Greater,self(), greater]),
    receive {less, LessSorted} -> true end,
    receive {greater, GreaterSorted} -> true end,
    Parent ! {Tag, LessSorted ++ [Pivot] ++
        GreaterSorted}.
```



Using Erlang

- Not installed on the lab machines
- Installed on SUCS
- Download from `http://www.erlang.org/`

Questions?