Erlang

Joe Armstrong

joe.armstrong@ericsson.com

Who is Joe?

Inventor of Erlang, UBF, Open Floppy Grid
Chief designer of OTP
Founder of the company Bluetail

Currently
Software Architect
Ericsson

Current Interests
Concurrency oriented programming
Peer-to-peer architectures
Grid computing
Functional programming

The world is concurrent

but we program in

sequential languages

This is

AMAZINGLY DIFFICULT

but

if we program

in a concurrent language

it

becomes

Really

Easy

Concurrency Oriented programming

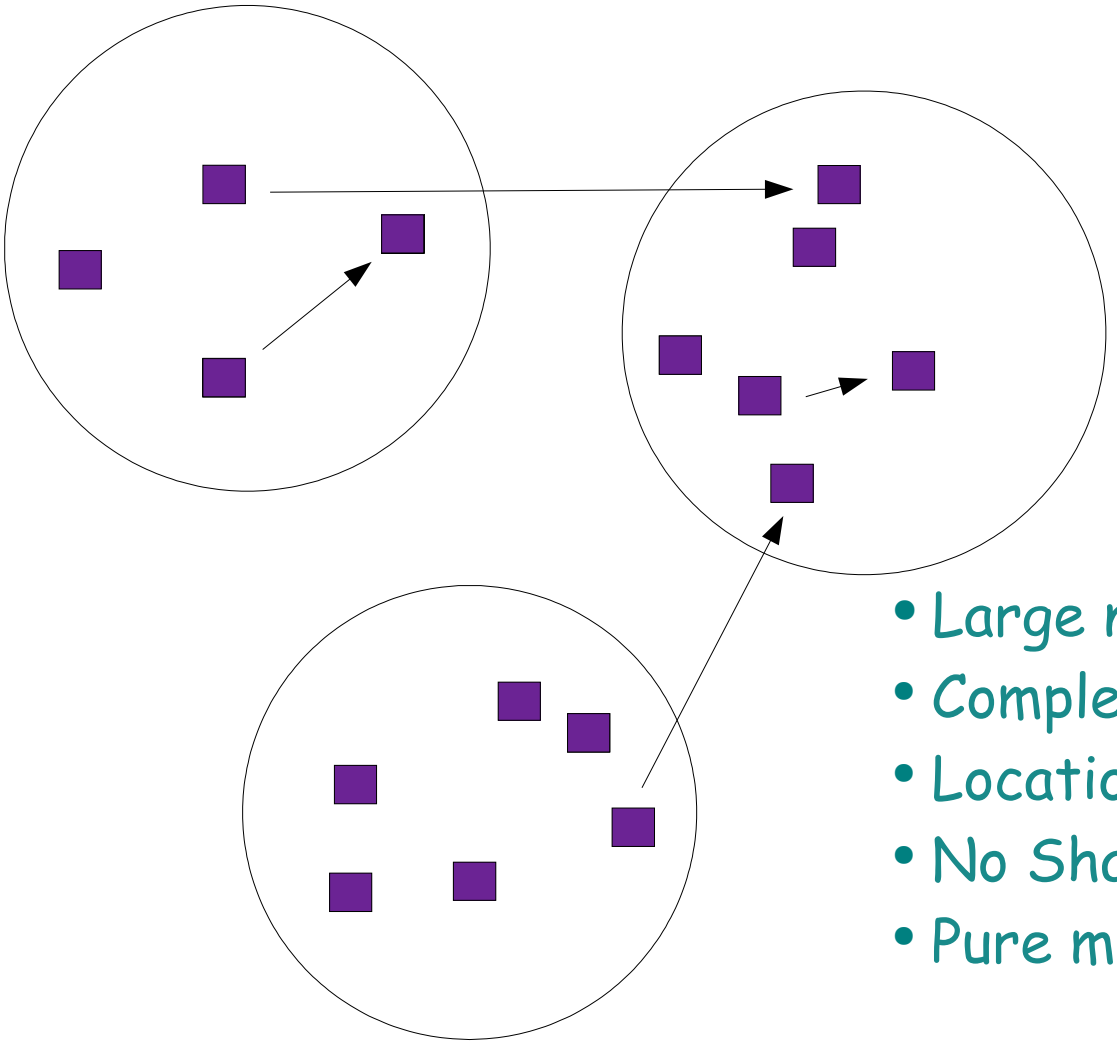
A style of programming where concurrency is used to structure the application

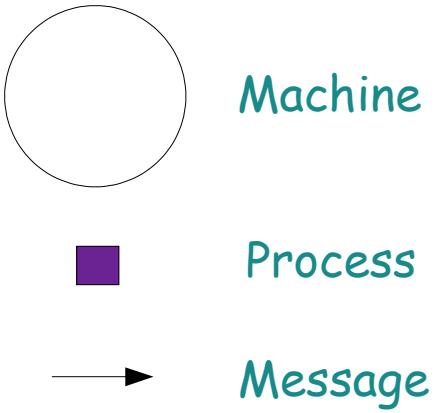
- Large numbers of processes
- Complete isolation of processes
- No sharing of data
- Location transparency
- Pure message passing

"My first message is that concurrency is best regarded as a program structuring principle."

Structured concurrent programming - Tony Hoare Redmond July 2001

What is COP?





- Large number of processes
- Complete isolation between processes
- Location transparency
- No Sharing of data
- Pure message passing systems

Why is COP nice?

- We intuitively understand concurrency
- The world is parallel
- The world is distributed
- Making a real-world application is based on observation of the concurrency patterns and message channels in the application
- Easy to make scalable, distributed applications

What is Erlang/OTP?

- Erlang = Concurrent Programming Language with a functional core
- OTP = a set of library routines callable by Erlang for writing fault-tolerant distributed applications

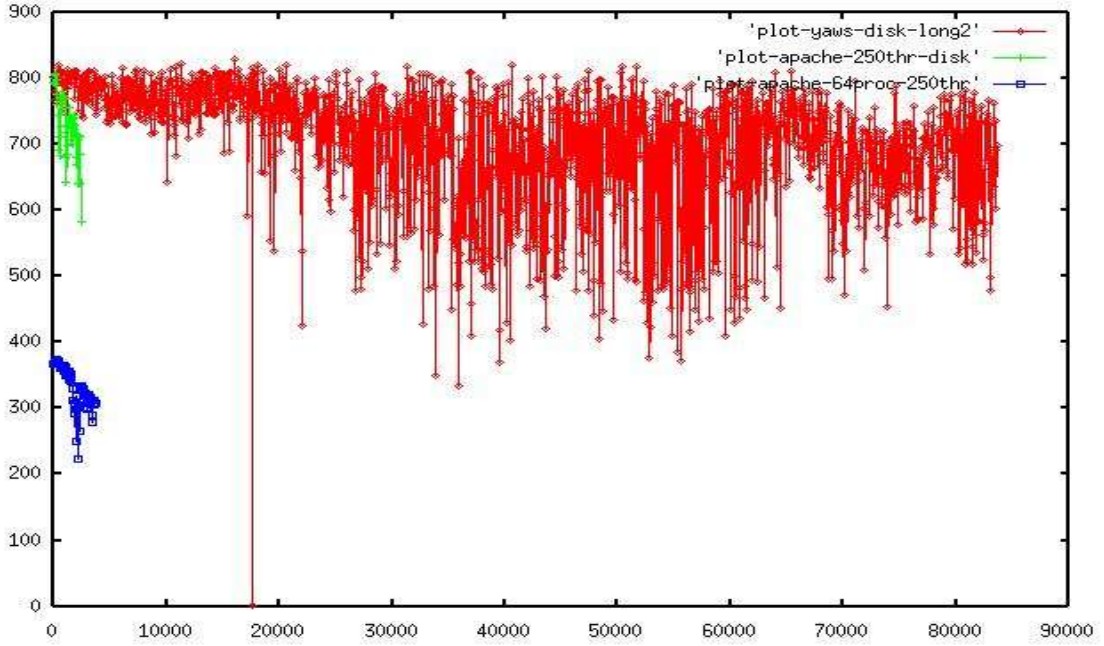
What is Erlang good for?

Programming distributed applications

Programming fault-tolerant applications

Programming applications with large numbers of parallel processes

Web server



Plot of throughput (in 100 Kbytes/Sec) vs. # parallel connections in simulated denial of service attack

- Red = YAWS (NFS)
- Green = Apache (NFS); Blue=Apache(local disk)
- Apache dies at 4000 parallel sessions
- See http://www.sics.se/~joe/apachevsyaws.html

Once upon a time ...

1986 – Pots Erlang (in Prolog)
1987 – ACS/Dunder
1988 – Erlang -> Strand (fails)
1989 – JAM (Joe's abstract machine)
1990 – Erlang syntax changes (70x faster)
1991 – Distribution
1992 – Mobility Server
1993 – Erlang Systems AB
1995 – AXE-N collapses. AXD starts
1996 – OTP starts
1998 – AXD deployed. Erlang Banned. Open Source Erlang.
Bluetail formed
1999 – BMR sold
2000 – Alteon buys Blutail. Nortel buys Alteon
2002 – UBF. Concurrency Oriented Programming
2003 – Ph.D. Thesis - Making reliable systems

History

- Erlang is an Ericsson secret
- Erlang is too slow
- Erlang is banned
- Erlang escapes (Open source)
- Erlang infects Nortel
- ...
- Erlang controls the world

Why should I learn yet another programming language?

Because it's fun .....
Because we can write beautiful program in it
Because my boss told me to
Because we can develop products quicker in it
Because it solves certain technical problems

If Erlang is the solution what is the problem?

How do we make reliable systems from components which fail?

How do we correct hardware failures?

Replicate the hardware

How do we correct software errors?

Having two identical copies of the software won't work – both will fail at the same time and for the same reason

Why does your computer crash?

Which fails more often, hardware or software?

Problem domain

Highly concurrent (hundreds of thousands of parallel activities)
Real time
Distributed
High Availability (down times of minutes/year – never down)
Complex software (million of lines of code)
Continuous operation (years)
Continuous evolution
In service upgrade

How do we make systems?

Systems are made of black boxes (components)

Black boxes execute concurrently

Black boxes communicate

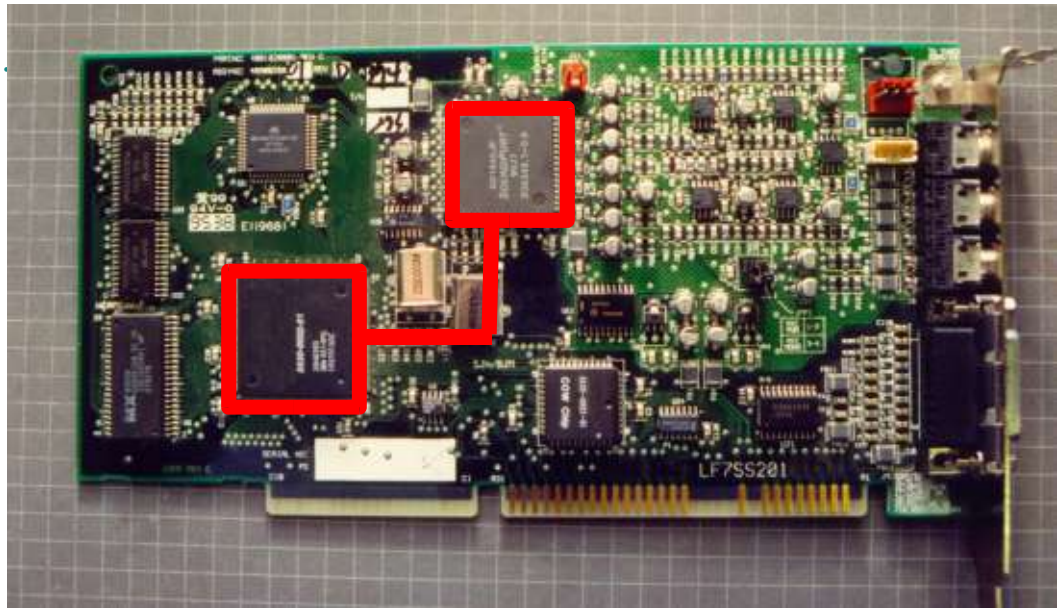
How the black box works internally is irrelevant

Failures inside one black box should not crash another black box

System requirements

R1. Concurrency	processes
R2. Error encapsulation	isolation
R3. Fault detection	what failed
R4. Fault identification	why it failed
R5. Live code upgrade	evolving systems
R6. Stable storage	crash recovery

Isolation



Hardware components operate concurrently are isolated and communicate by message passing

Consequences of Isolation

Processes have share nothing semantics and data must be copied

Message passing is the only way to exchange data

Message passing is asynchronous

GOOD STUFF

Processes

Copying

Message passing

BAD STUFF

Threads

Sharing

Mutexes

Synchronized methods

Language

My program should not be able to crash your program
Need strong isolation and concurrency

Processes are OK – threads are not (threads have shared resources)

Can't use OS processes (Heavy – semantics depends on OS)

Isolation

My program should not be able to crash your program.

This is the single most important property that a system component must have

All things are not equally important

Java doesn't work

...The only safe way to execute multiple applications, written in the Java programming language, on the same computer is to use a separate JVM for each of them, and to execute each JVM in a separate OS process. This introduces various inefficiencies in resource utilization, which downgrades performance, scalability, and application startup time. The benefits the language can offer are thus reduced mainly to portability and improved programmer productivity. Granted these are important, but the full potential of language-provided safety is not realized. Instead there exists a curious distinction between ``language safety,'' and ``real safety''.

... tasks cannot directly share objects, and that the only way for tasks to communicate is to use standard, copying communication mechanisms

- Czajkowski, and Daynes,Sun Microsystems

Nor does C and C++

No processes (OS has processes but not C or C++)
Terrible isolation pointers etc.
Non-portable (word sizes,big-/little-endian problems)
No GC

But Erlang works

Lightweight processes (lighter than OS threads)
Good isolation (not perfect yet ...)
Programs never loose control
Error detection primitives
Reason for failure is known
Exceptions
Garbage collected memory
Lots of processes
Functional

Agner Krarup Erlang (1878-1929)

Erlang

You can create a parallel process

```
Pid = spawn(fun() -> ... end).
```

then send it a message

```
Pid ! Msg
```

and then wait for a reply

```
receive
    {Pid, Rely} ->
        Actions
end
```

It typically takes 1 microsecond to create a process or send a message

Processes are isolated

Programming for Failure

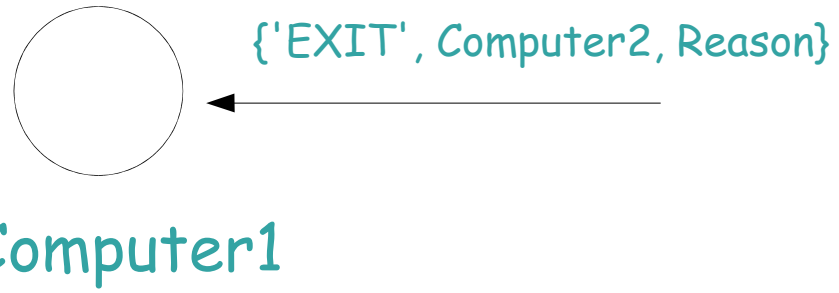
Let it crash

If you can't do what you are supposed to do crash as soon as possible – don't make matters worse by trying to fix the errors.

Let some other process fix the error

Let some other process fix the error

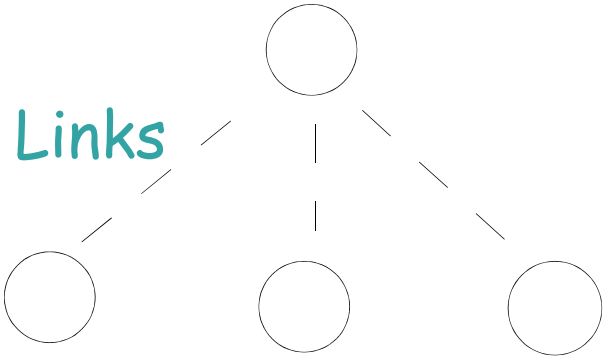
To do fault-tolerant computing you need at least TWO computers



Which means you can't share data

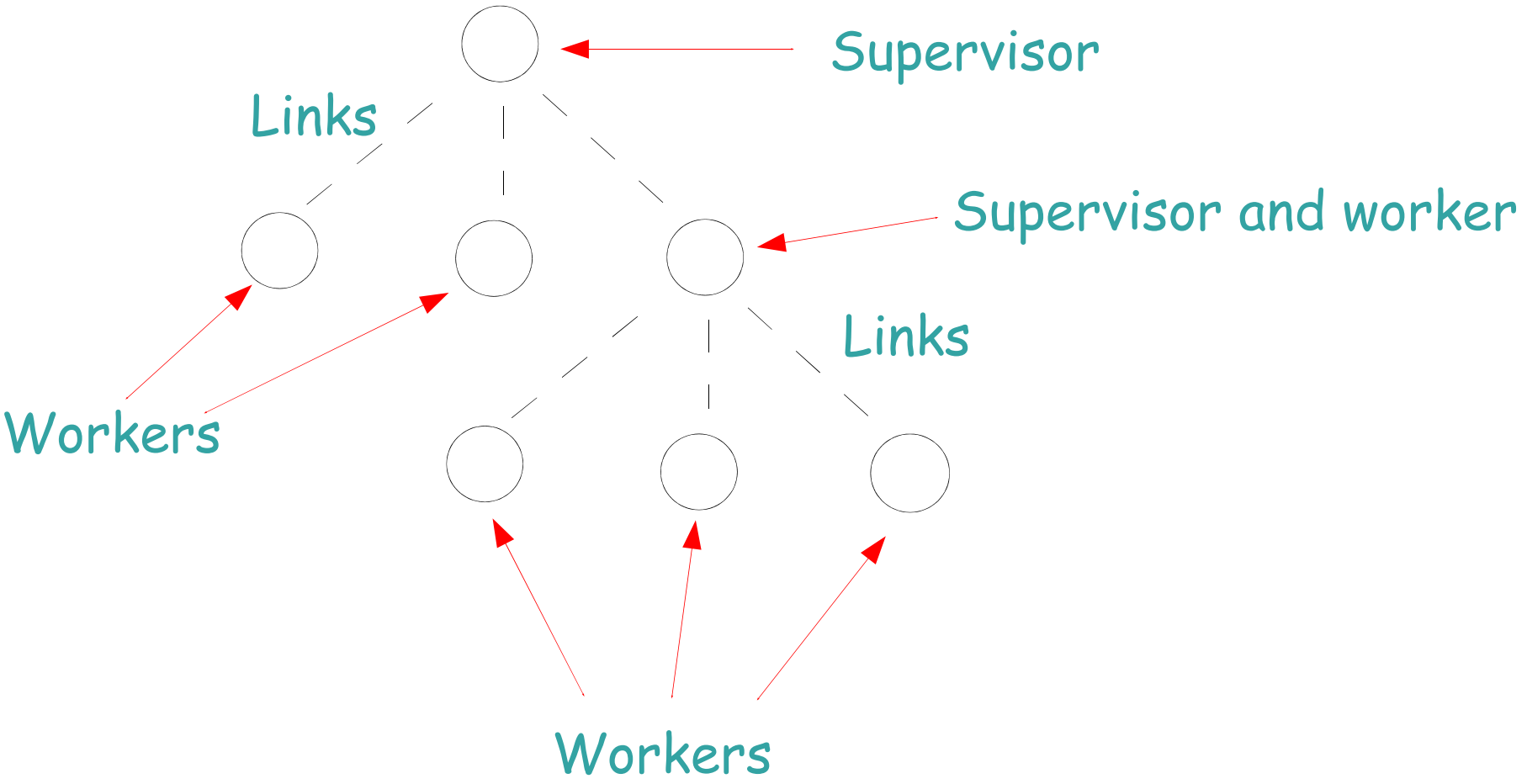
Programming for errors

If you can't do what you want to do try and do something simpler



The supervisor monitors the workers and restarts them if they fail

A supervision hierarchy



OTP behaviours

Generic libraries for building components of a real-time system.

Includes

Client-server
Finite State machine
Supervisor
Event Handler
Applications
Systems

Following or leading?

How can we make world class exciting innovative products using exactly the same technology as everybody else?

You can't – you must do something different

If you use the same techniques as everybody else (Java, C, C++, UML) you should achieve the same results as everybody else)

Doing something different involves risk. But

You either win or you loose

Either way, you learn and you have fun

If you loose you try again

Erlang success stories

Ericsson AXD301
Ericsson GPRS system
Alteon (Nortel) SSL accelerator
Alteon (Nortel) SSL VPN
Teba Bank (credit card system – South Africa)
T-mobile SMS system (UK)
Open Poker - 27K Games, 137K Players, 800K processes on one laptop

AXD301

- ATM switch
- 11% of world market
- 99.9999999 % reliability (9 nines)
- 30-40 Million calls/week
- World's larges telephony over ATM network
- 1.7 million lines of Erlang

ERICSSON

ENGINE Integral proves outstanding capacity capability….

BT, UK (ENGINE Integral in Hybrid configuration)

During the very popular "Pop Idol" TV show in February 2002, the Ericsson server in Ilford was on two occasions exposed to 3.4 and 2.8 MBHCA. The dynamic congestion control kicked in and limited the throughput to the configured 1.4 MBHCA. The situation was handled smoothly and did not cause any problems with the server.

In September 2002, 14 nodes has been deployed out of planned 23 nodes by the end of 2002. BT are handling about 30-40 Million calls per node and week. In total BT has switched circa 7 Billion calls to date using VoATM Technology and ATM Transport (September 2002).

Source: Ericsson , BT

ERICSSON

BT, UK chooses Ericsson and ENGINE Integral for migration of it's transit telephony network to the world's largest Telephony over ATM network

Situation: Business Drivers

- Existing transit circuit-switched network needed modernization
- Rapid traffic growth from new and existing services
- Increase capacity and reduce cost through evolution to new multi-service communication system capable of carrying all telephony, data and multi-media services

Solution

- Partnership
- ENGINE Integral in hybrid configuration for >50% of BT transit network - 23 nodes across UK
- Management system
- Live cut-over from NB switches

Result

- 14 nodes carrying live traffic September 2002 out of planned 23 before end of 2002 (according to time plan)
- 99,9999999% availability
- 30-40 Million calls per week & node
- World's largest Telephony over ATM network
- Best Supplier of the year, 2000

40

31 ms. / year

SSL Accelerator

- Market leader
- 48% of world market (2002)

Projects

- 28 projects at sourceforge
  - YAWS (Yet another web server)
  - Eddie (Cluster/load balancer)
  - WAP gateway
  - Wings (3-D graphics modelling)
  - 3D gameing
- 72 Projects in Jungerl
  -