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Thinking in a Highly Concurrent, Mostly-functional Language

GOTO Berlin

Berlin, December 4th 2015

Francesco Cesarini
Founder & Technical Director

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francesco@erlang-solutions.com

Erlang Training and Consulting Ltd

Thinking in a Highly Concurrent, Mostly-functional Language

QCON London, March 12th, 2009

Francesco Cesarini
francesco@erlang-consulting.com

```
counter_loop(Count) ->
   receive
      increment ->
         counter_loop(Count + 1);
      {count, To} ->
         To ! {count, Count},
         counter_loop(Count)
    end.
```

Erlang

Erlang SOLUTIONS

After you've opened the top of your head, reached in and turned your brain inside out, this starts to look like a natural way to count integers. And Erlang does require some fairly serious mental readjustment.

However… having spent some time playing with this, I tell you...

Tim Bray, Director of Web Technologies – Sun Microsystems

Erlang SOLUTIONS

… If somebody came to me and wanted to pay me a lot of money to build a large scale message handling system that really had to be up all the time, could never afford to go down for years at the time, I would unhesitatingly choose Erlang to build it in.

Tim Bray, Director of Web Technologies – Sun Microsystems

Erlang SOLUTIONS

Syntax

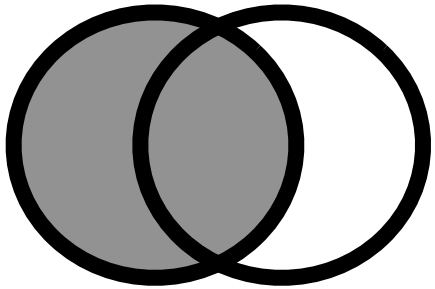
Erlang SOLUTIONS

Concurrency

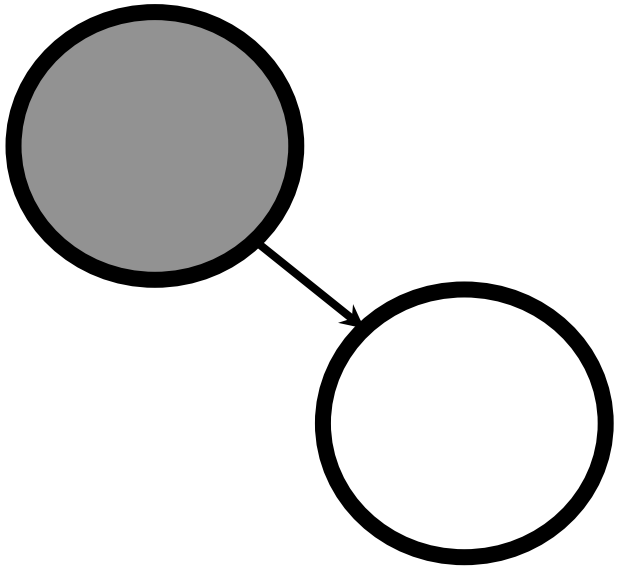
Erlang SOLUTIONS

Two ways to do concurrency

Mutable State

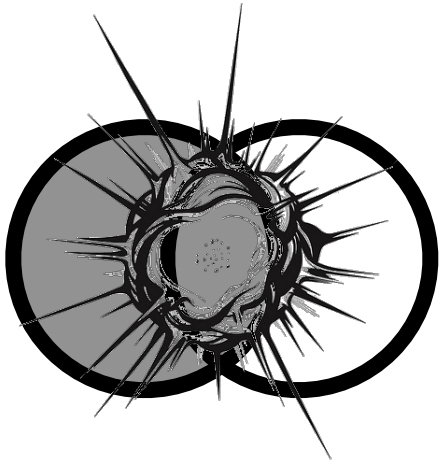


Immutable State



Erlang SOLUTIONS

Two ways to do concurrency

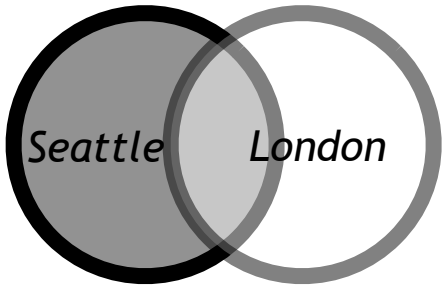


Problem 1 with mutable state:

Your program crashes whilst executing in the critical section…

Erlang SOLUTIONS

Two ways to do concurrency

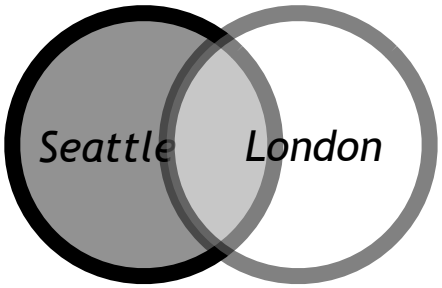


Problem 2 with mutable state:

Where do you locate your state…

Erlang SOLUTIONS

Two ways to do concurrency

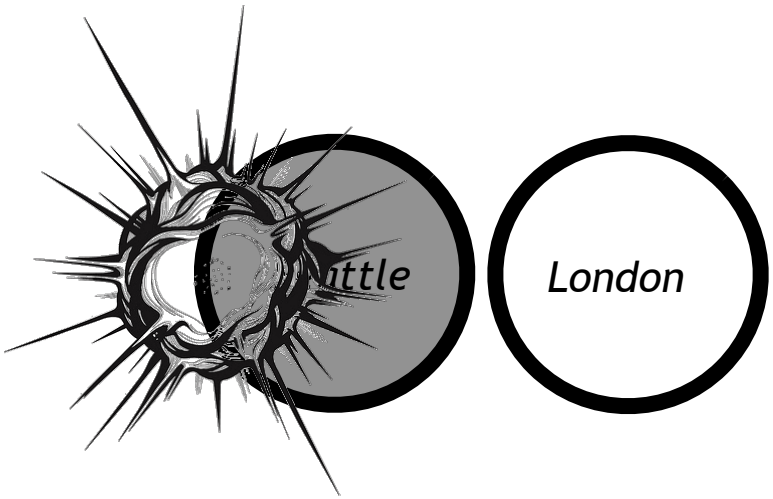


Problem 3 with mutable state:

What happens if your network connectivity fails…

Erlang SOLUTIONS

Two ways to do concurrency



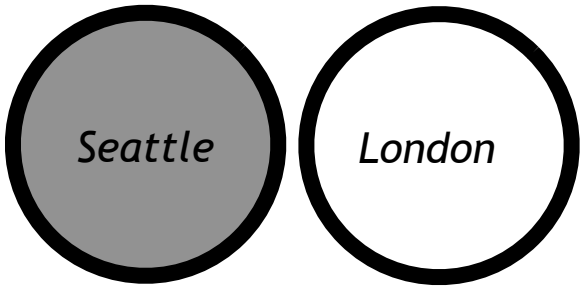
Problem 1 with mutable state:

Your program crashes whilst executing in the critical section…

*Your state **does not get corrupted**.*

Erlang SOLUTIONS

Two ways to do concurrency



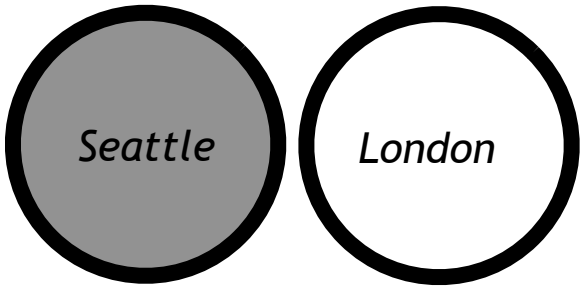
Problem 2 with mutable state:

Where do you locate your state…

You do not Locate state, you copy it.

Erlang SOLUTIONS

Two ways to do concurrency



Problem 3 with mutable state:

What happens if your network connectivity fails…

Make sure your business logic and databases handle network splits!

Erlang SOLUTIONS

Erlang Highlights: Concurrency

Creating a new process using spawn

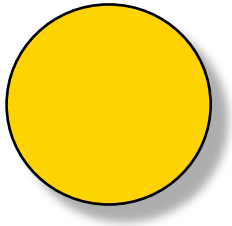
```
-module(ex3).
-export([activity/3]).

activity(Name,Pos,Size) ->
    ..........
```

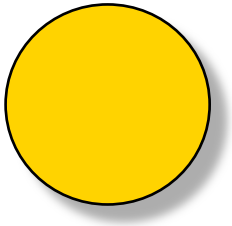

```
Pid = spawn(ex3,activity,[Joe,75,1024])
```


Erlang SOLUTIONS

Erlang Highlights: Concurrency

Processes communicate by asynchronous message passing





```
Pid ! {data,12,13}
```

```
receive
     {start} -> ……
     {stop} -> ……
     {data,X,Y} -> ……
end
```


Erlang SOLUTIONS

Products: AXD301 Switch - 1996

A Telephony-Class, scalable (10 – 160 GBps) ATM switch

Designed from scratch in less than 3 years

AXD 301 Success factors:

- Competent organisation and people
- Efficient process
- Excellent technology (e.g. Erlang/OTP)

Erlang SOLUTIONS

Products: AXD301 Switch - 1996

Erlang: ca 1.5 million lines of code

- Nearly all the complex control logic
- Operation & Maintenance
- Web server and runtime HTML/ JavaScript generation

C/C++: ca 500k lines of code

- Third party software
- Low-level protocol drivers
- Device drivers

Java: ca 13k lines of code

- Operator GUI applets

Erlang SOLUTIONS

Concurrency Modeling

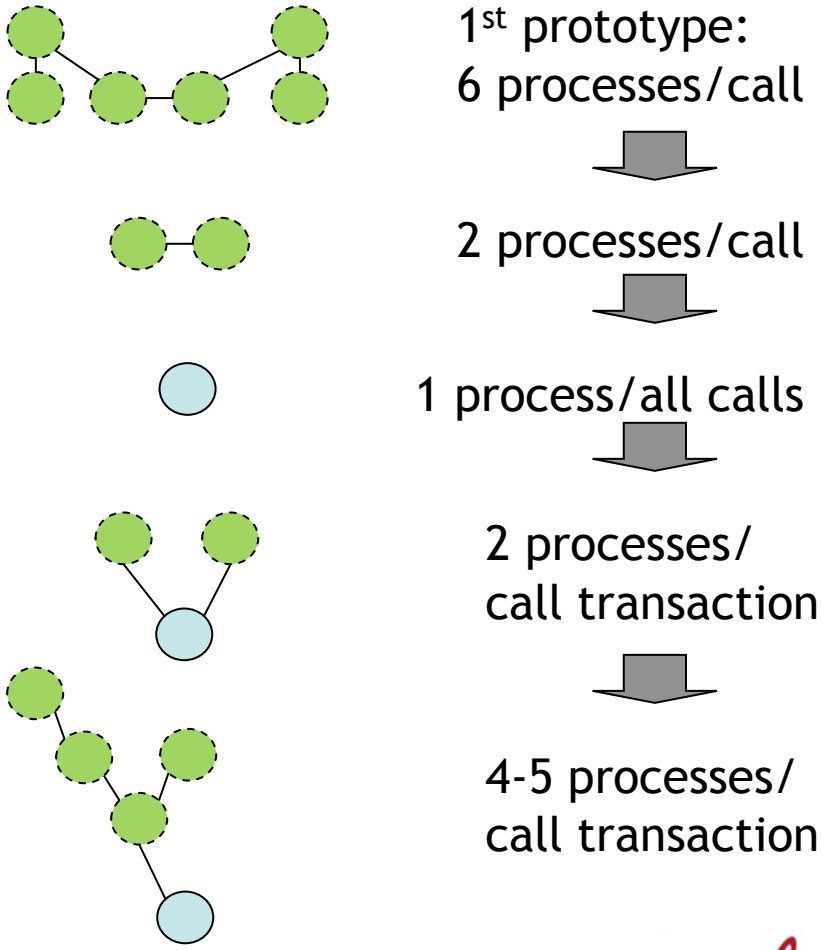
Model for the natural concurrency in your problem

In the old days, processes were a critical resource

- Rationing processes led to complex and unmanageable code

Nowadays, processes are very cheap: if you need a process – create one!

Example: AXD301 process model

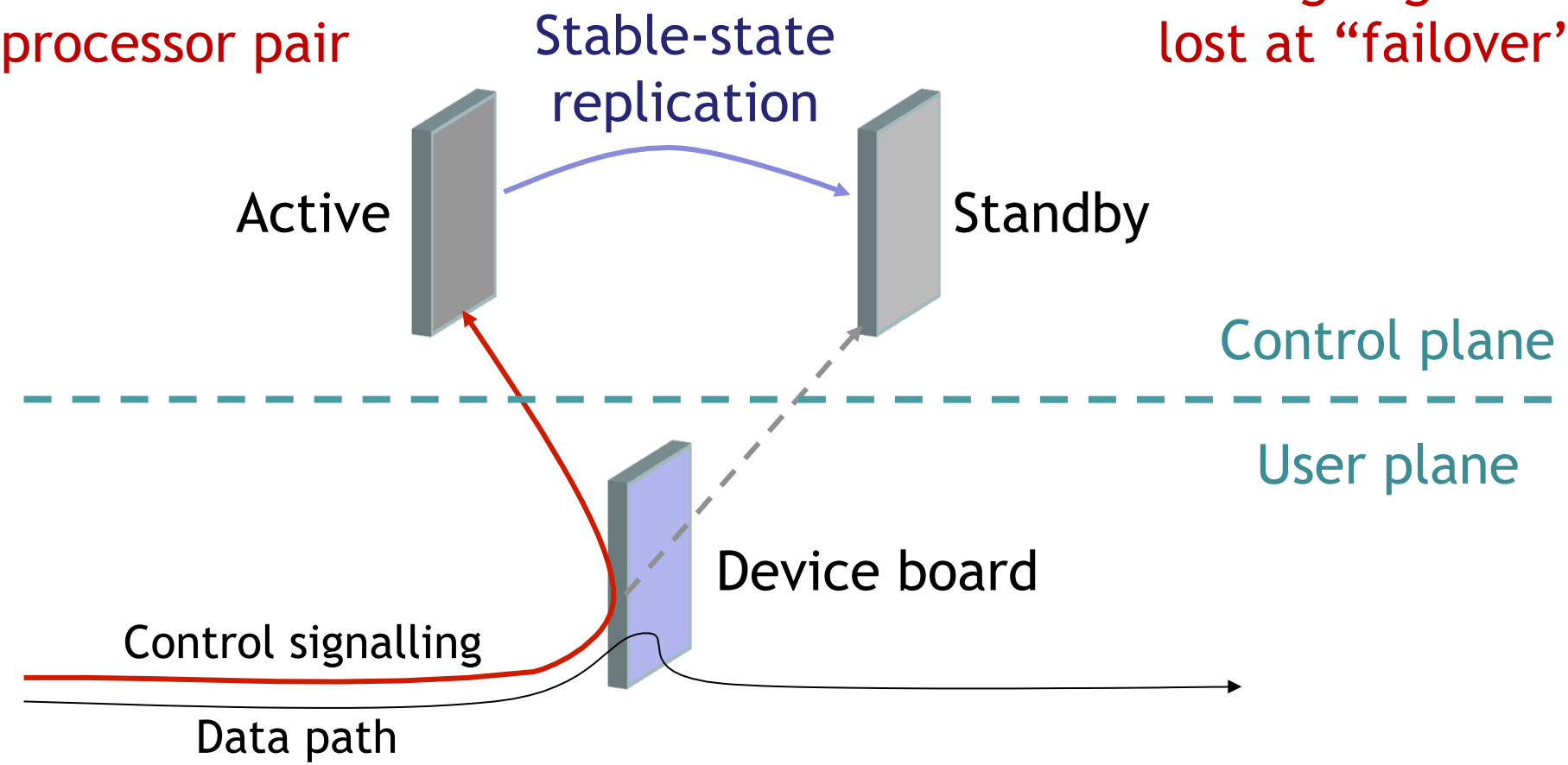


Erlang SOLUTIONS

1+1 Redundancy – Good ol' Telecoms

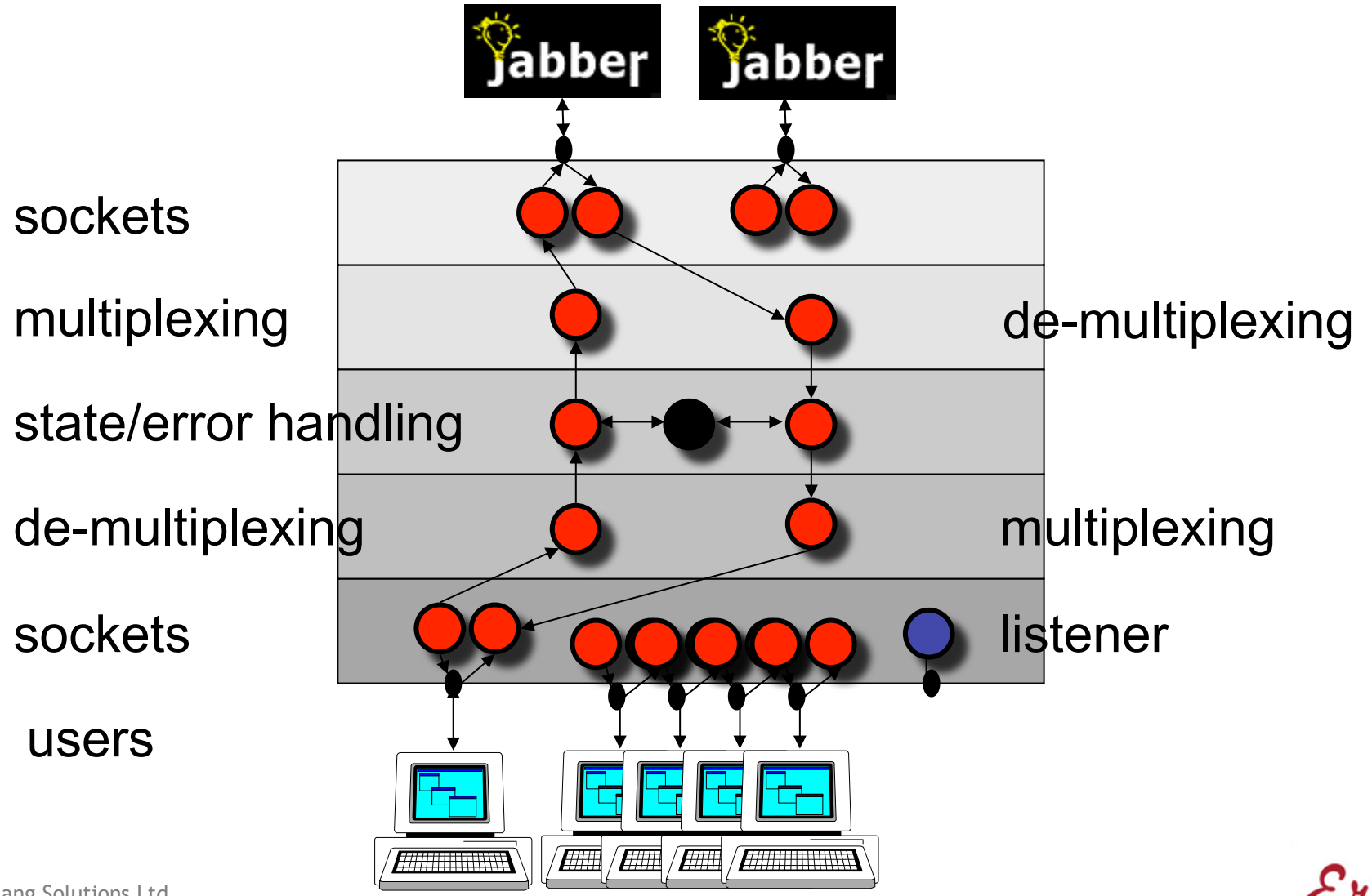
~ 35 000 calls
per processor pair

No ongoing sessions
lost at "failover"



Erlang SOLUTIONS

First IM Proxy Prototype - 2000



Erlang SOLUTIONS

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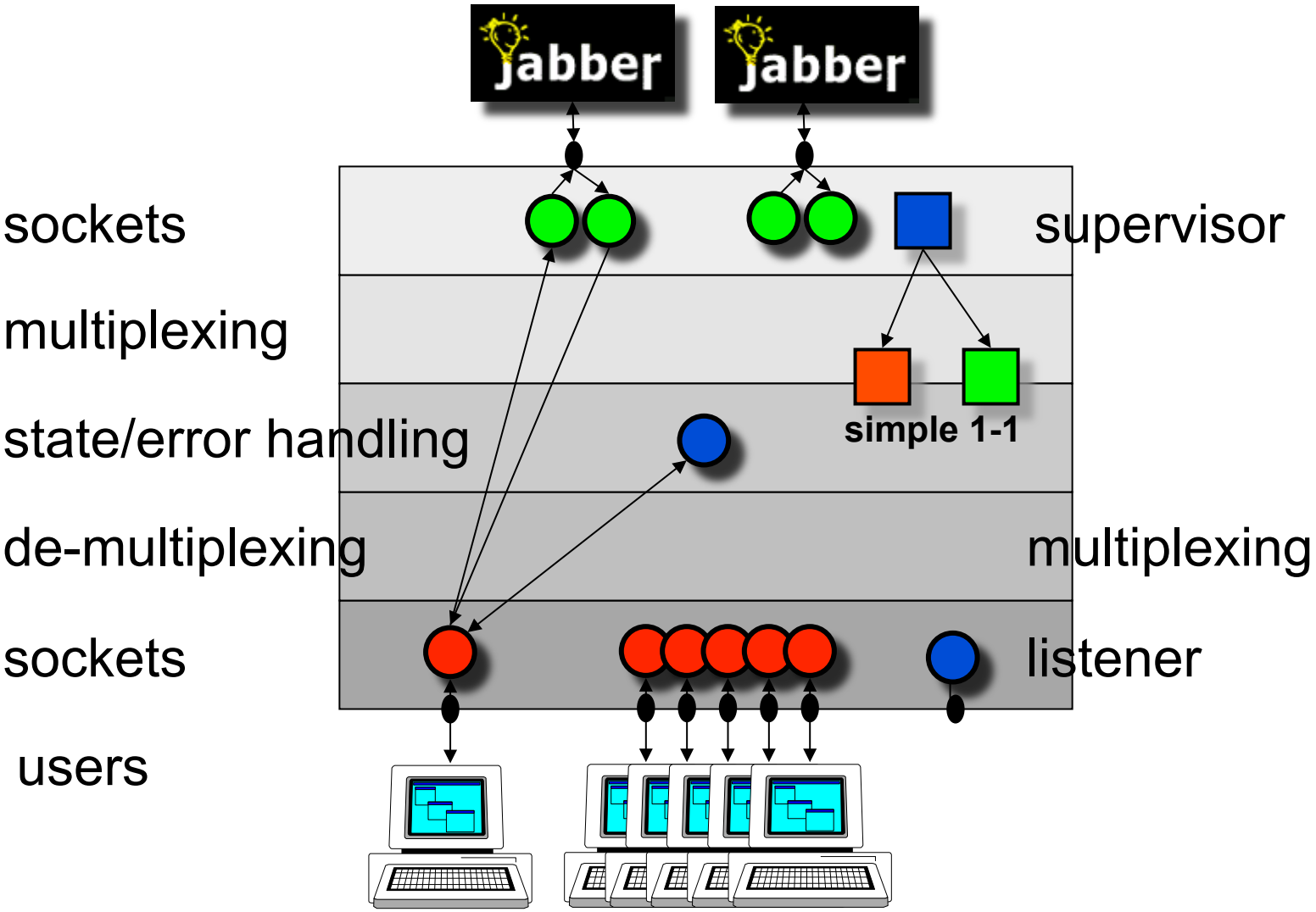

Erlang SOLUTIONS

Products: EjabberD IM Server - 2002

A distributed XMPP server

Started as an Open Source Project by *Alexey Shchepin*

Commercially Supported by Process-One (Paris)

- 40% of the XMPP IM market
- Used as a transport layer
- Managed 30,000 users / node

Erlang SOLUTIONS

Products: EjabberD IM Server - 2002

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- 40% of the XMPP IM market
- Used as a transport layer
- 2008, Managed 30,000 users / node

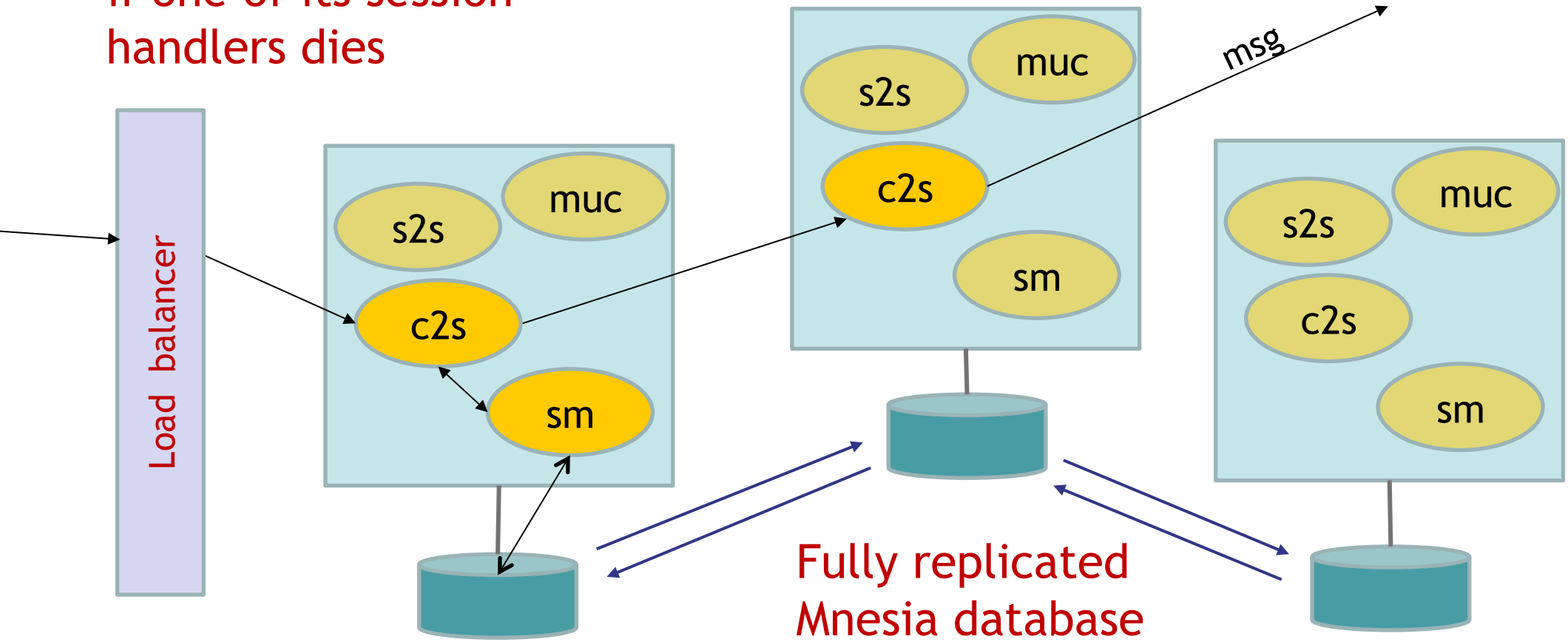
MongooseIM is a fork and rewrite

- Open Source, supported by Erlang Solutions
- Used for Messaging and Device Management
- 2014, managed 1 million users / node

Erlang SOLUTIONS

Fully Replicated Cluster - Ejabberd 2002

Client must re-connect
if one of its session
handlers dies



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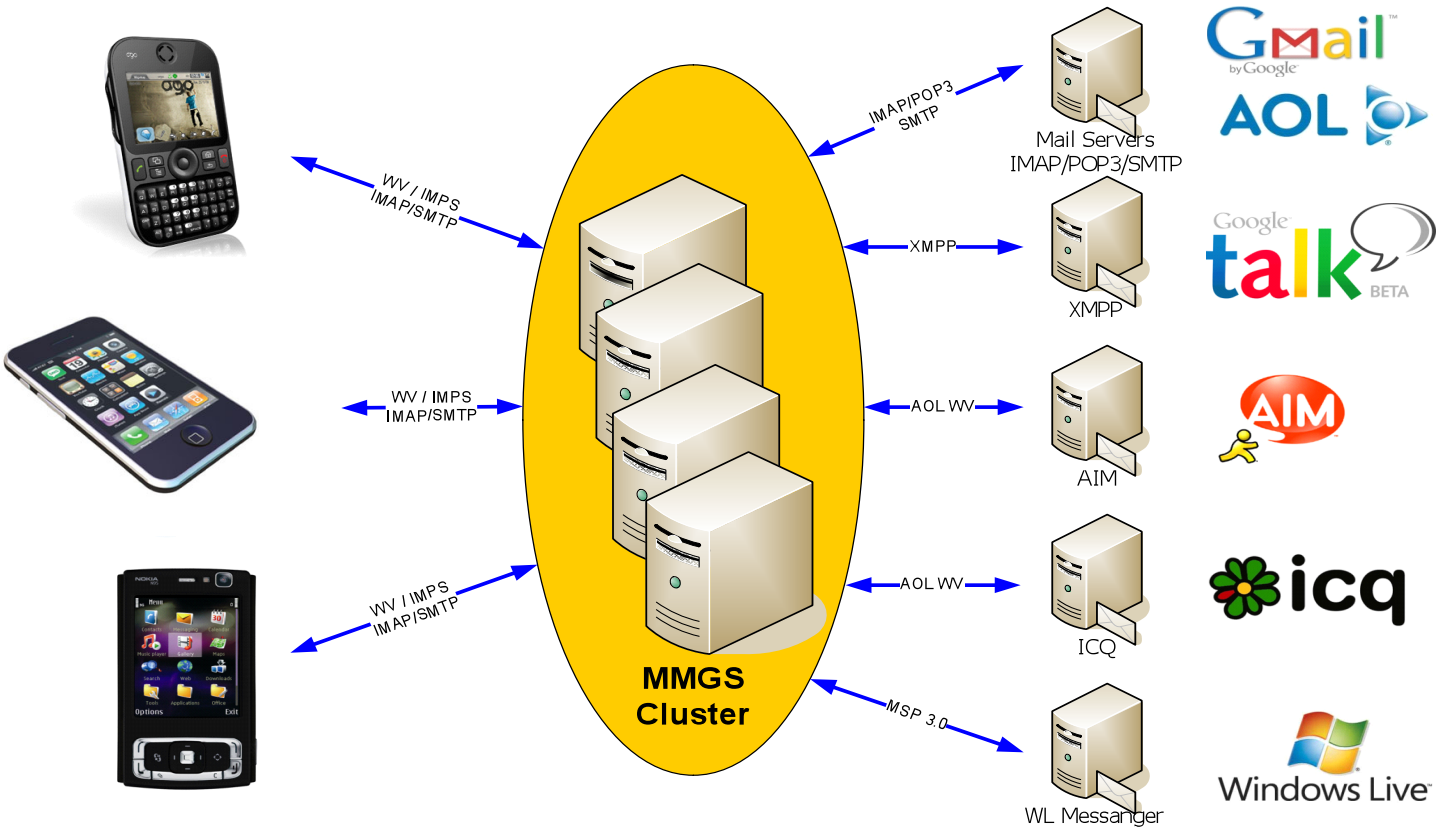
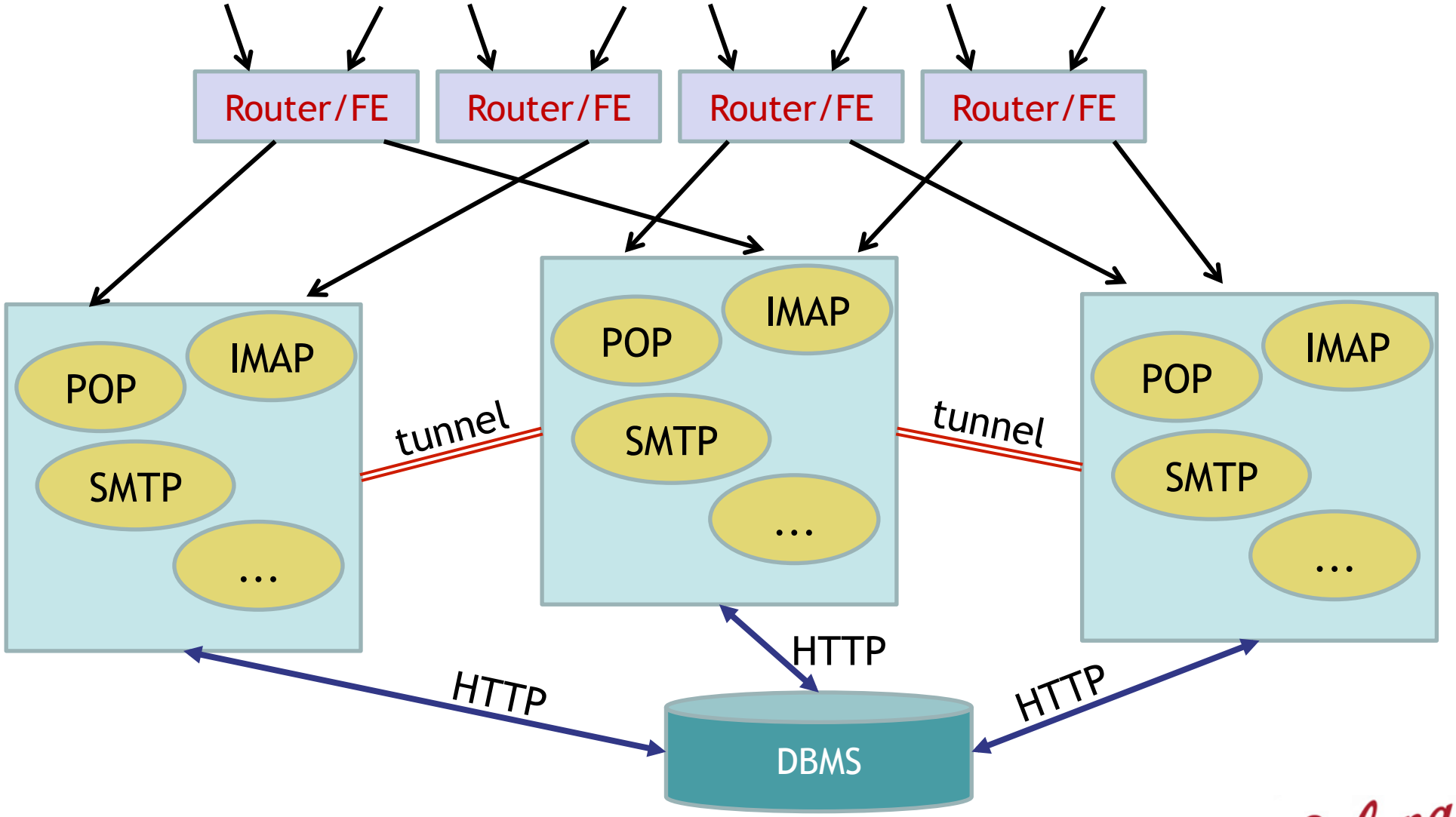
MMGS- Messaging Gateway - 2008



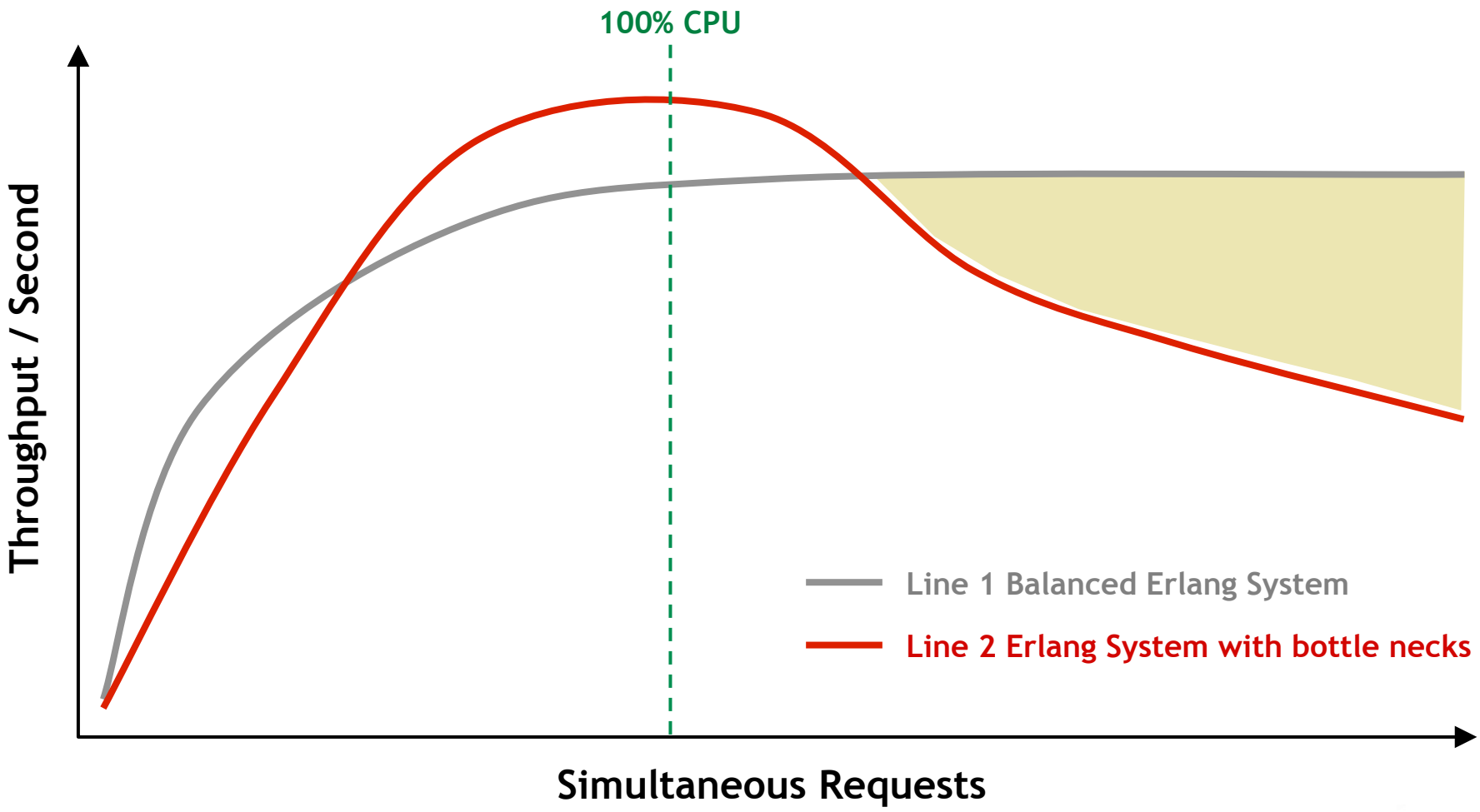
Erlang SOLUTIONS

MMGS- Messaging Gateway - 2008



Erlang SOLUTIONS

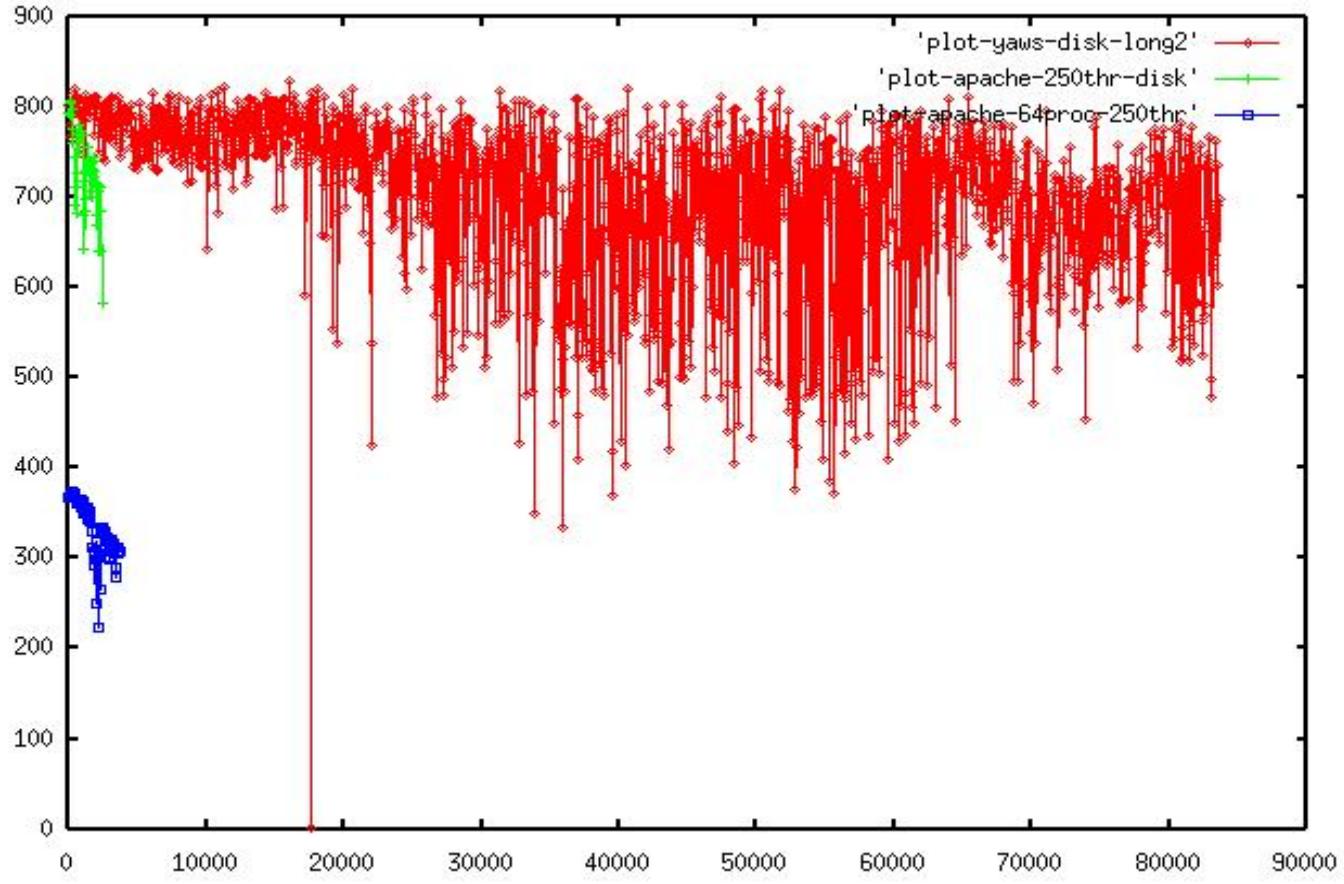
Erlang Concurrency Under Stress – Pre-SMP



Erlang SOLUTIONS

Erlang Concurrency Under Stress – Pre-SMP

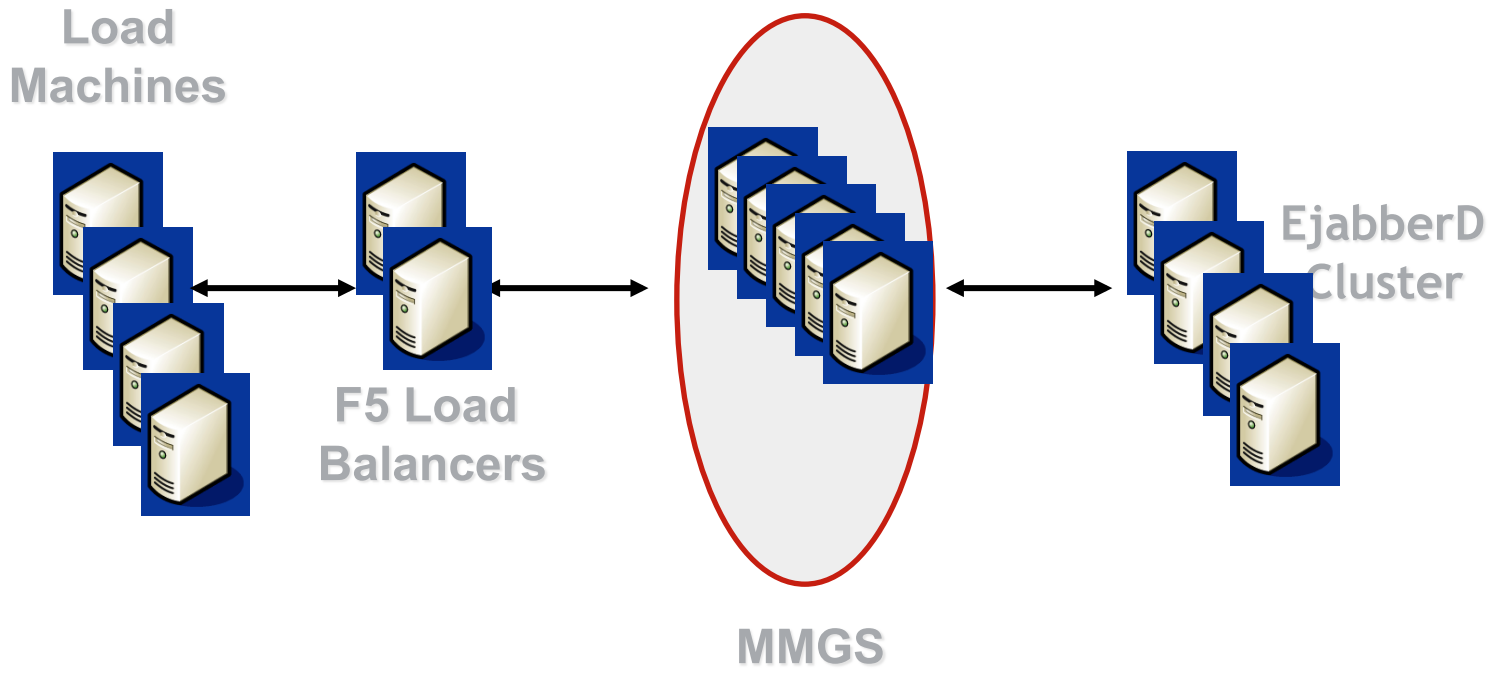
YAWS Throughput
(KBytes/second)



Simultaneous Requests

Erlang SOLUTIONS

Erlang Concurrency Under Stress – Post-SMP



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Stress Tests With SMP

I/O Starvation

TCP/IP Congestion

Memory Spikes

Timeout Fine-tuning

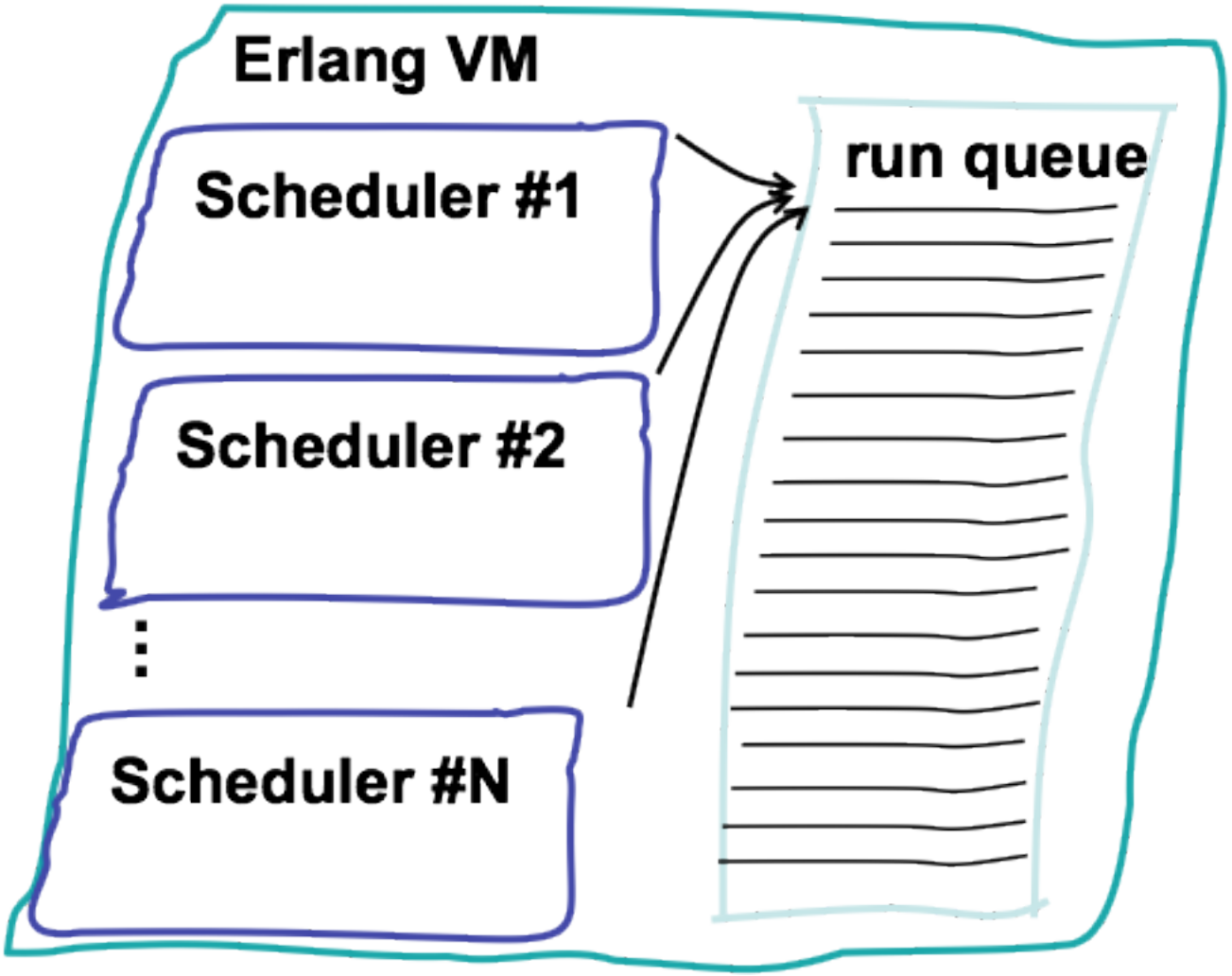
OS Limitations

ERTS Configuration Flags

Shut down Audit Logs

Erlang SOLUTIONS

SMP bottlenecks – pre 2008



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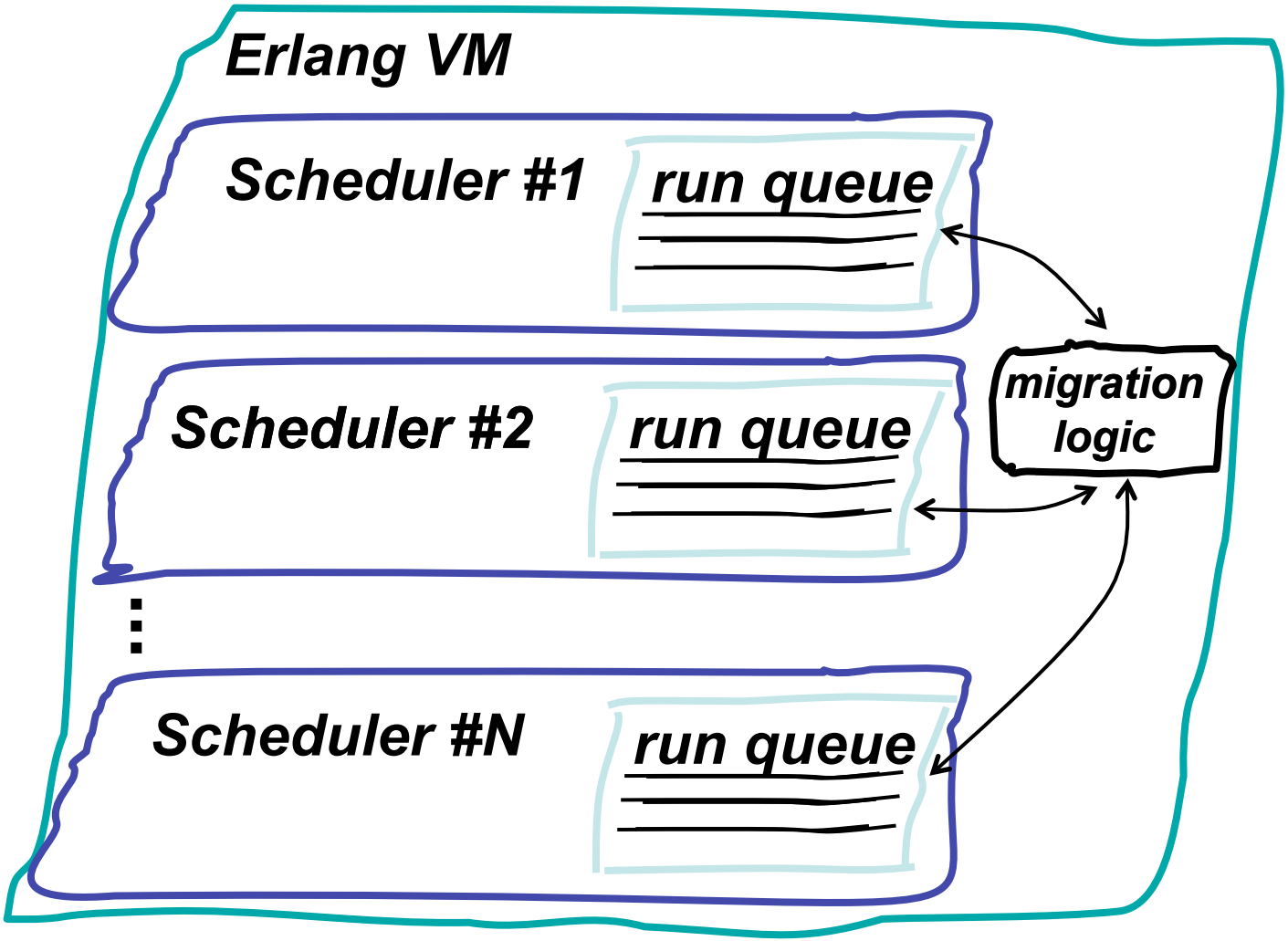
SMP bottlenecks – post 2008



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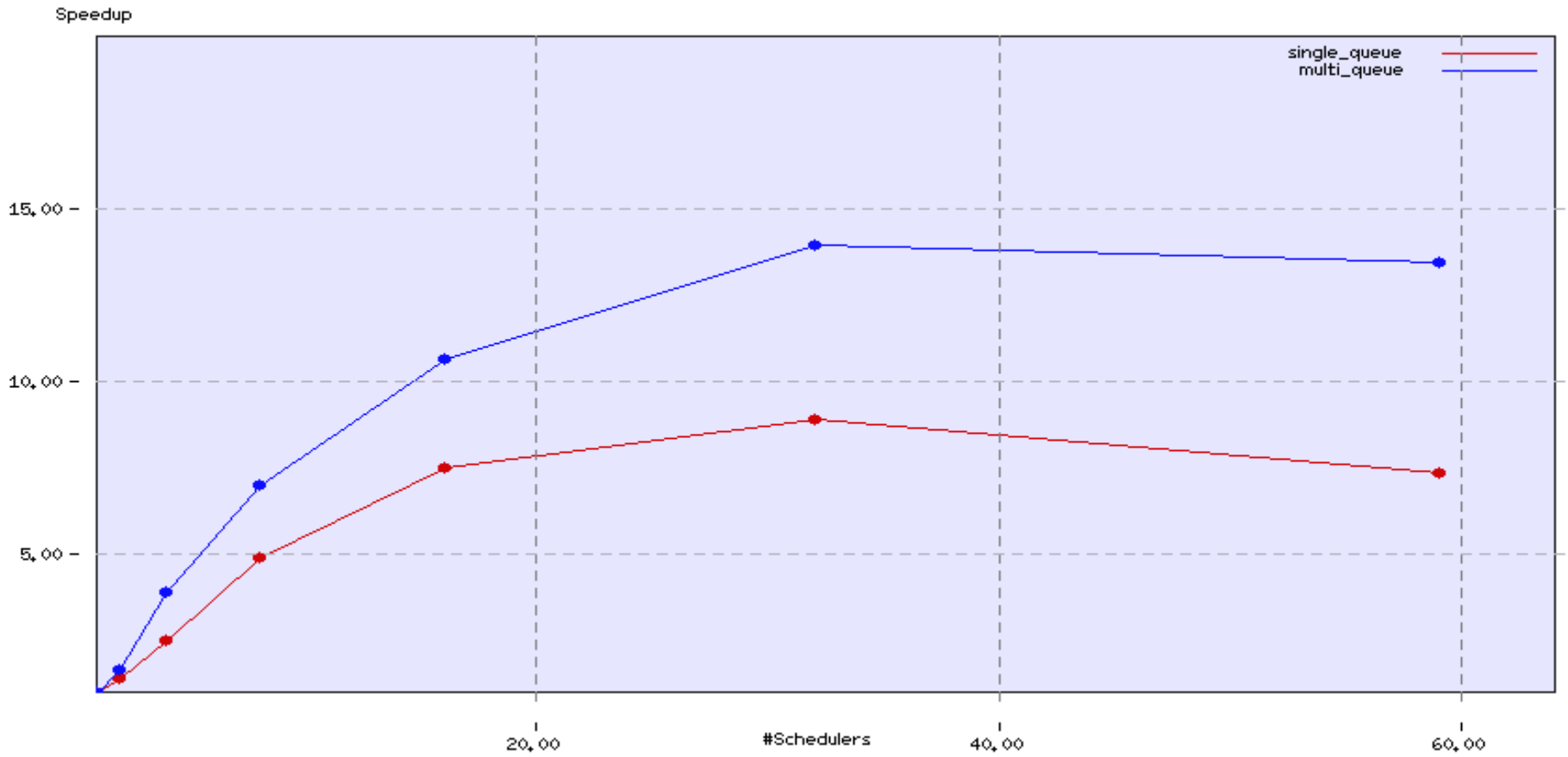
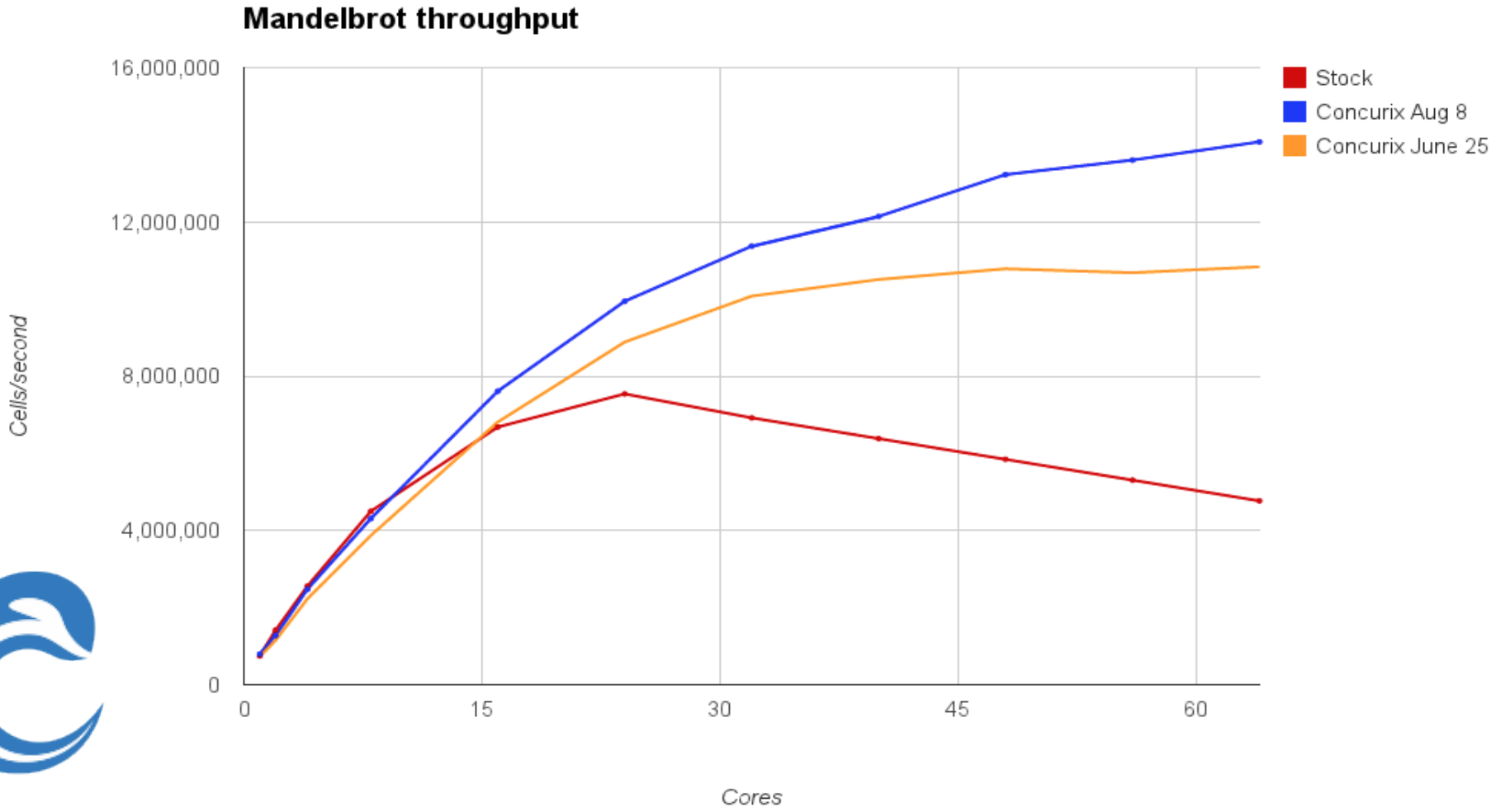
Big Bang Benchmark – post 2008



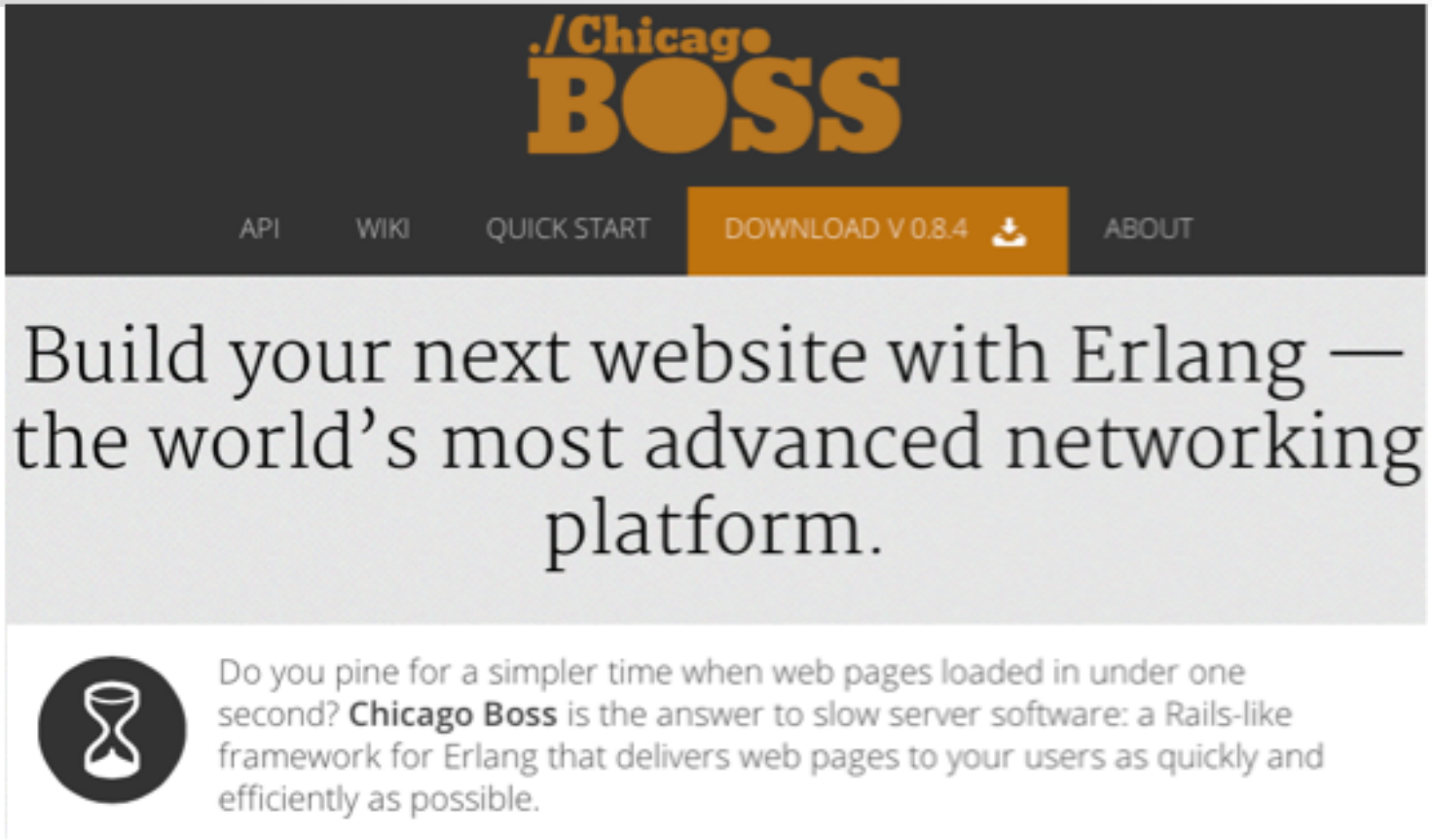
Red: *Single Queue,* ***Blue:*** *Multple Run Queue on a Tilera TilePro64 (64 cores)*

Erlang SOLUTIONS

Mandelbrot- 2013



Now for the Bottlenecks



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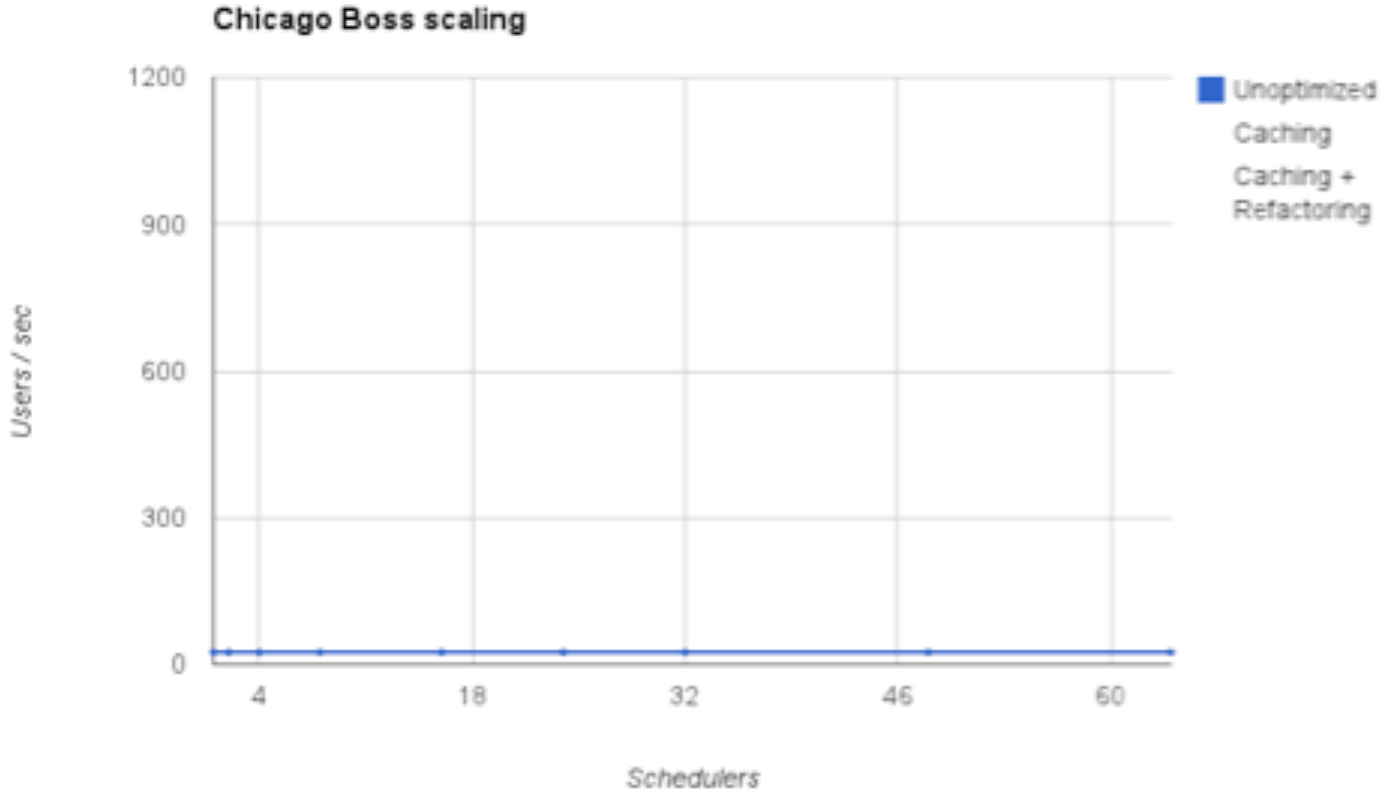
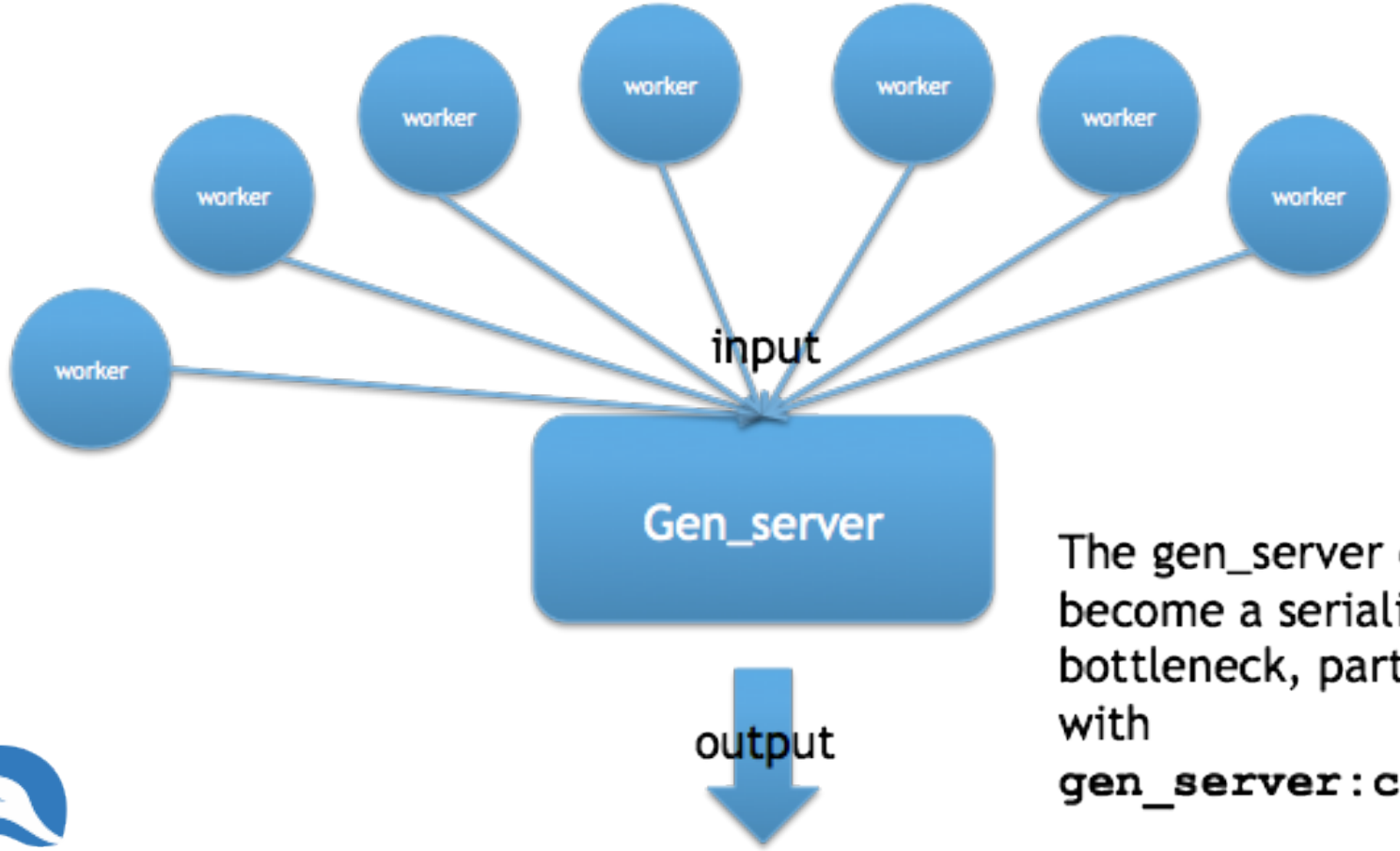
Now for the Bottlenecks



Now for the Bottlenecks



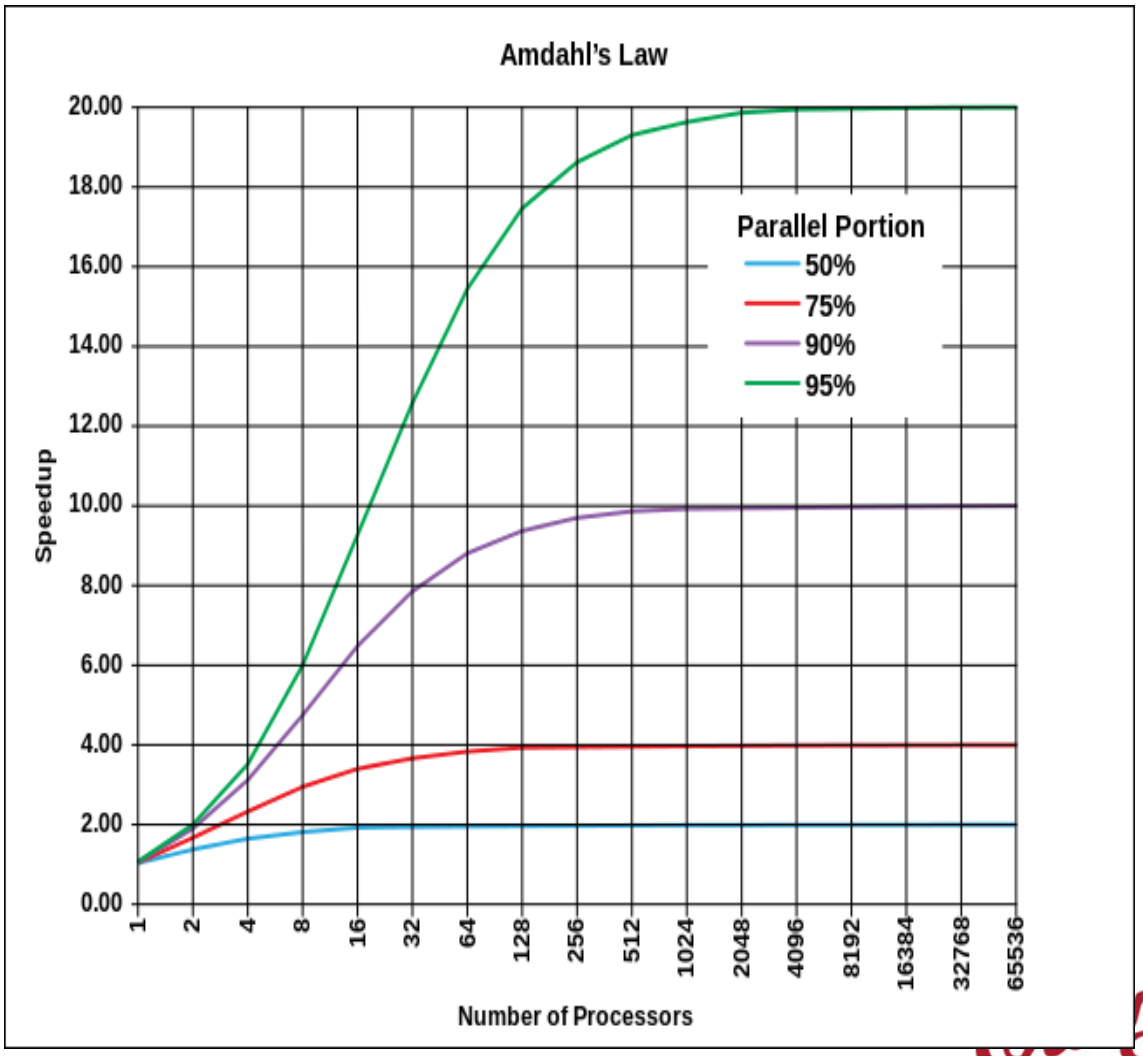
The gen_server can become a serialization bottleneck, particularly with `gen_server:call(...)`

Erlang SOLUTIONS

Ahmdal's Law

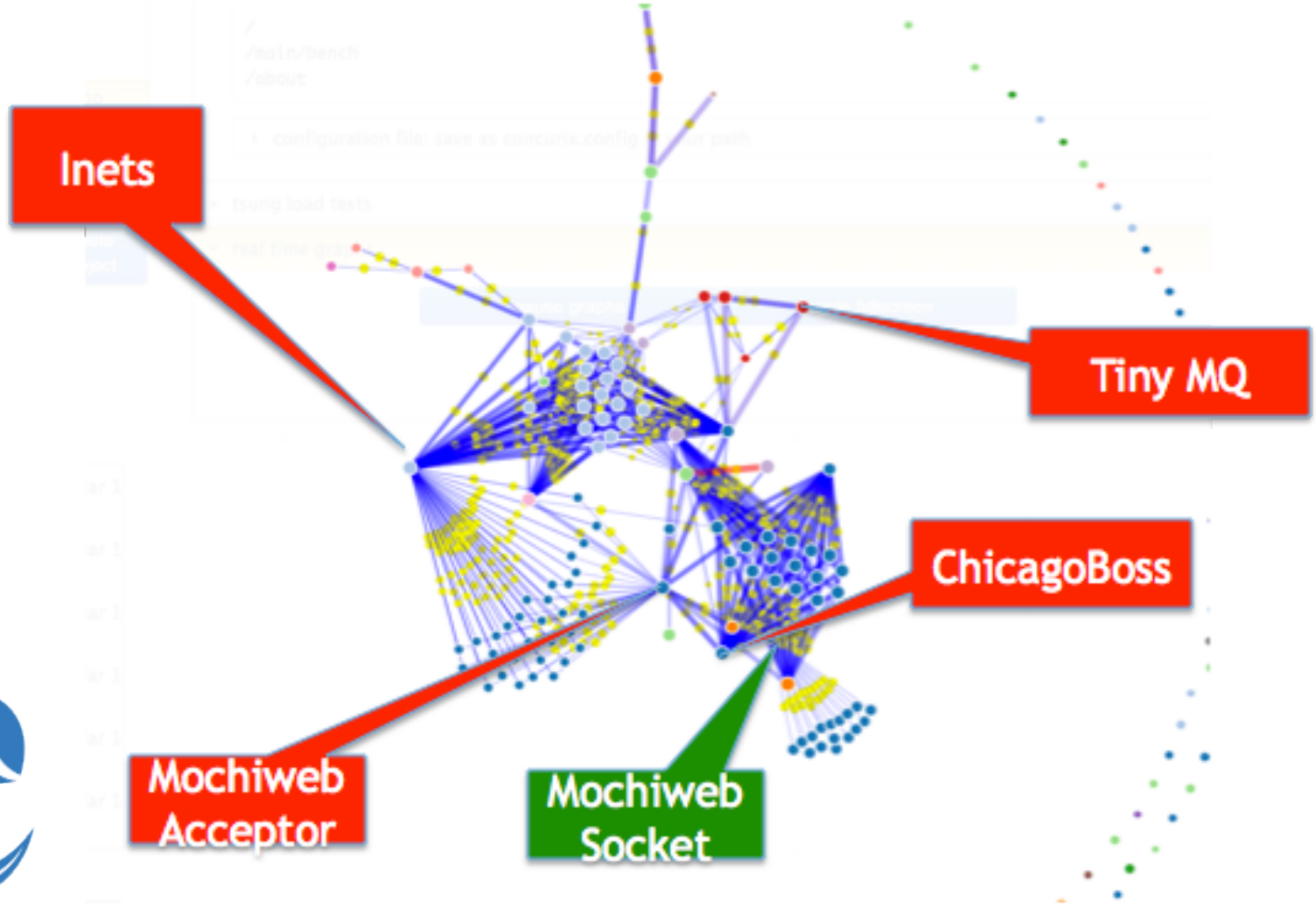
$$T(n) = T(1)\left(B + \frac{1}{n}(1 - B)\right)$$

- *n - the number of threads of execution*
- *B - the fraction of the algorithm that is strictly serial*
- *n - Number of parallel threads*
- *T(n) = The time an algorithm to finish when being executed on n thread(s)*



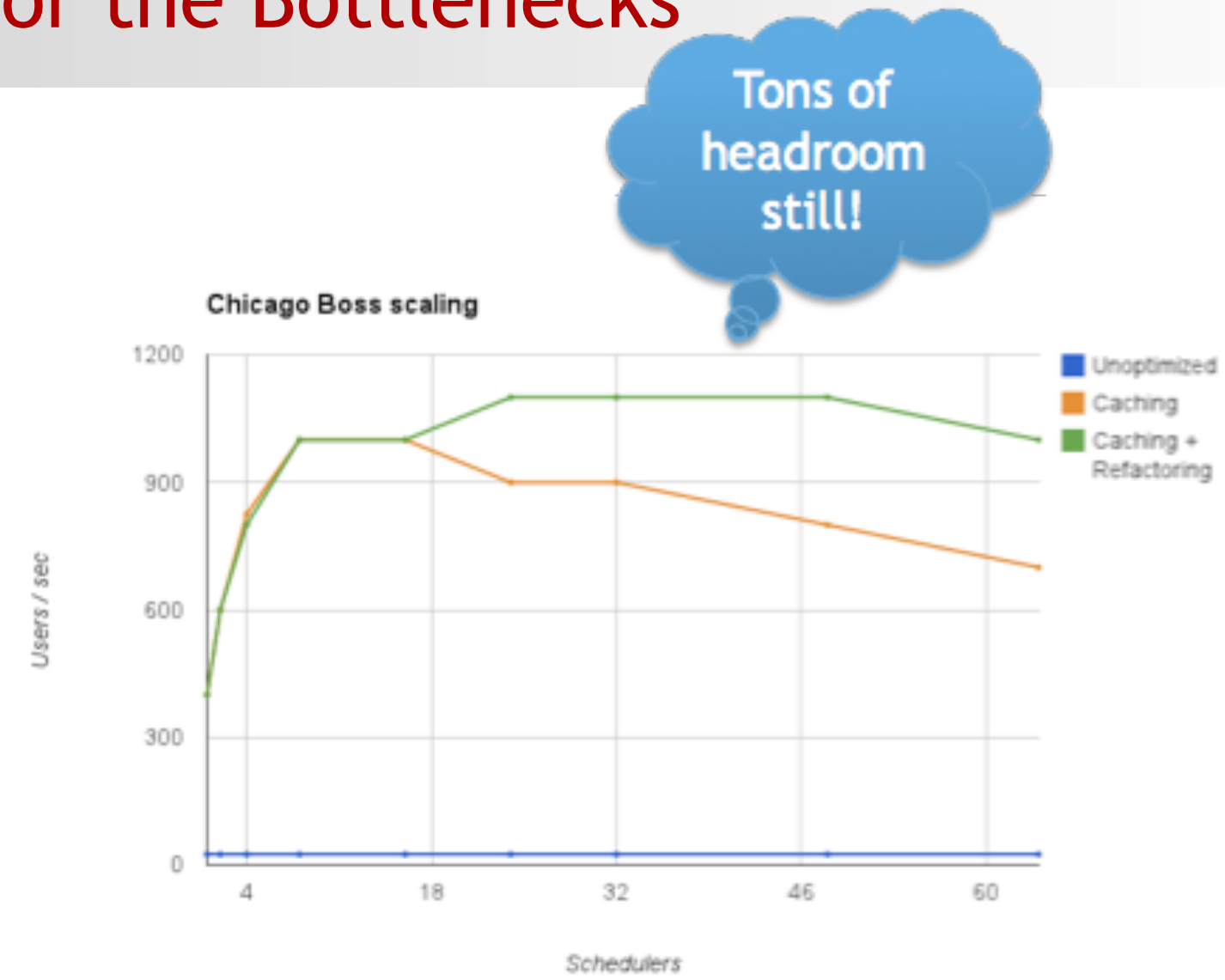
Now for the Bottlenecks

www.concurix.com



Erlang SOLUTIONS

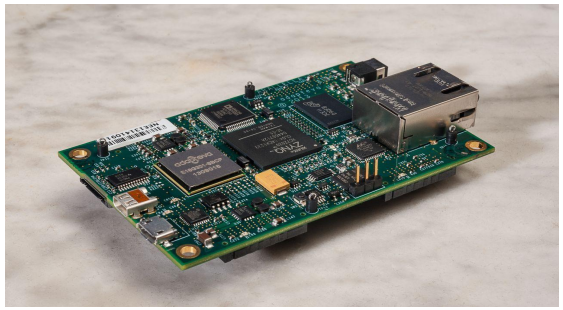
Now for the Bottlenecks



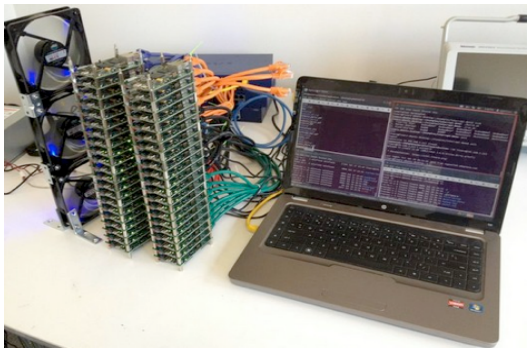
Heterogeneous multi-core hardware is here to stay

Different cores doing different things
CPUs, GPUs, FPGA

Parallella Board
Dual core ARM processor + FPGA
1GB RAM + MicroSD Card



16 or 64 core Epiphany co-processor
Gigabit Ethernet
2x USB ports + HDMI port



Erlang SOLUTIONS

Heterogeneous multi-core hardware

Andreas Olofsson
@adapteva

Following

Erlang now runs on 32KB Epiphany thanks to heroic efforts of Kostis and Magnus at Uppsala...P2=epiphany:spawn(..)
mlang.se/presentation.p…

RETWEETS 36 FAVORITES 42

2:05 PM - 8 Jul 2015

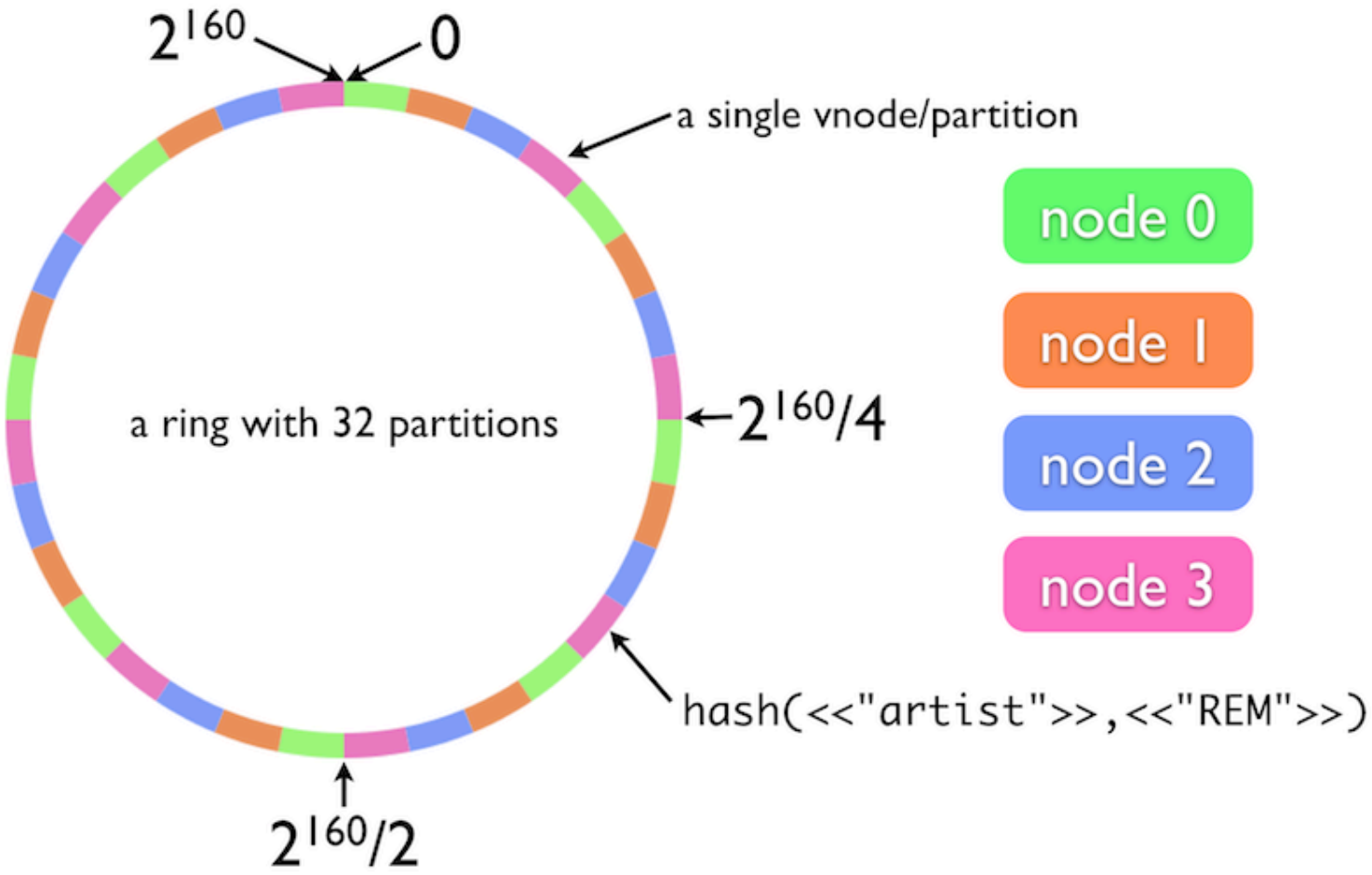
The Fastest Computer in the World!

Tianhe-2
Chinese National University of Defence Technology

- *33.86 petaflops/s (November 2013)*
- *16,000 Nodes, each with 2 Ivy Bridge multicores and 3 Xeon Phis*
- *3,120,000 x86 cores in total*

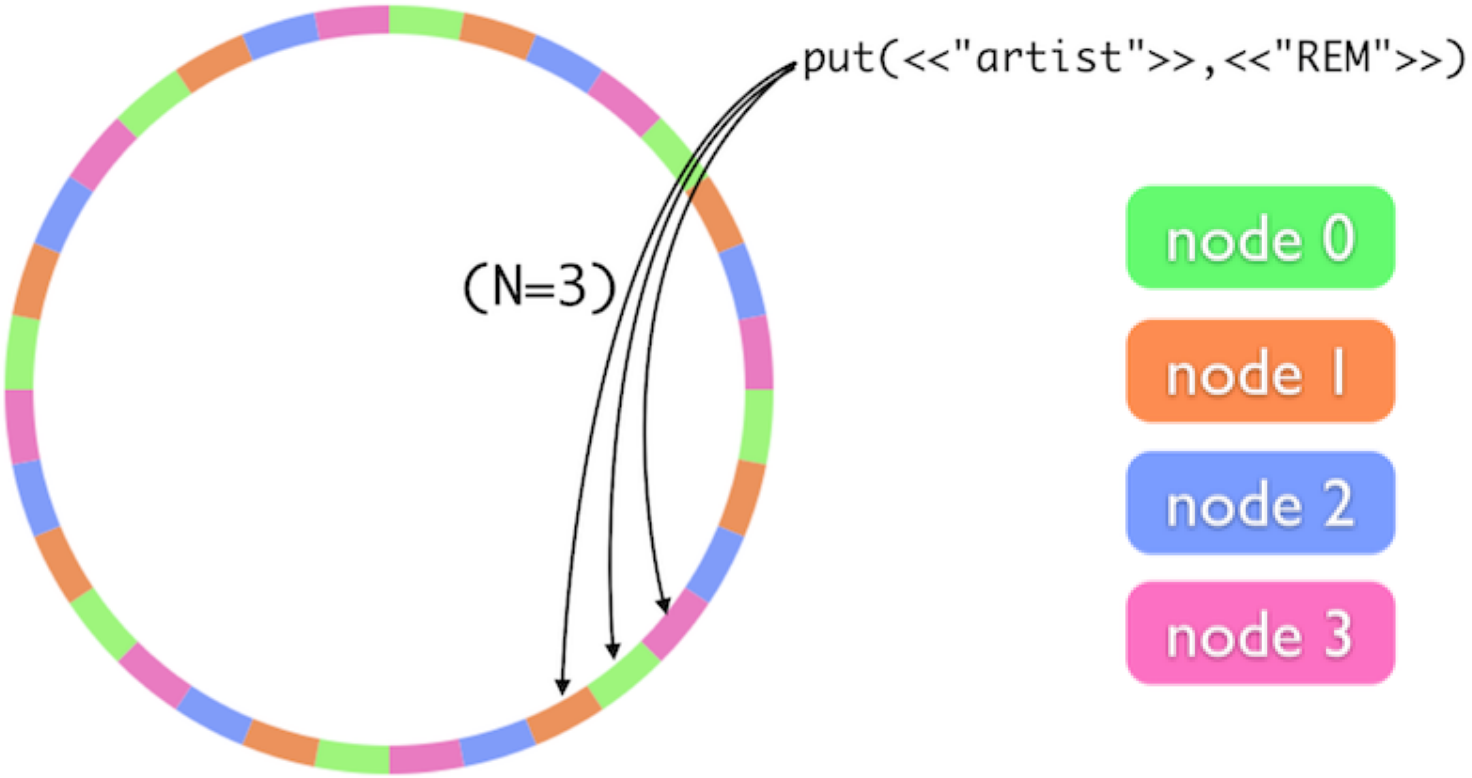
Erlang Solutions

Riak and other scalable architectures

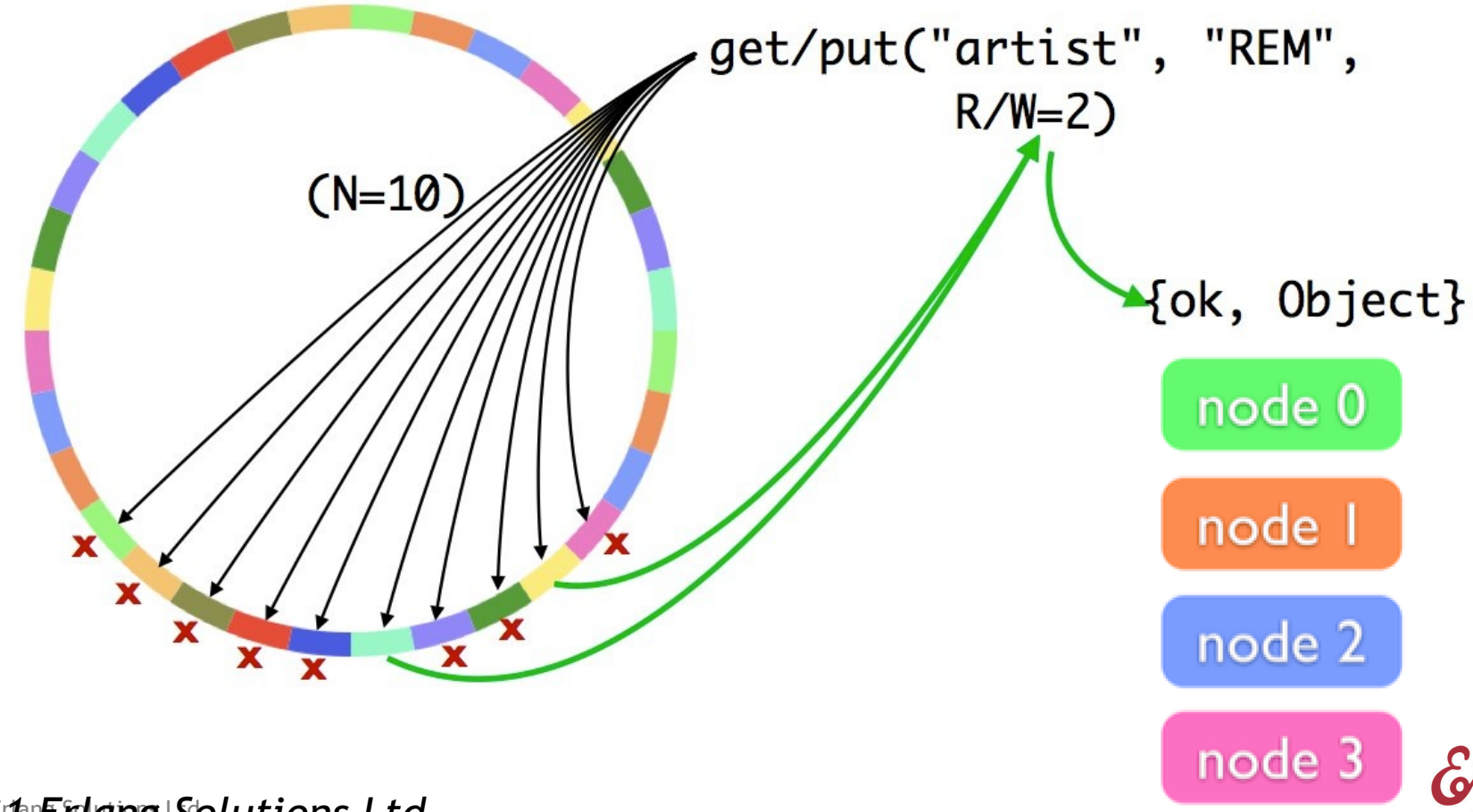


Erlang SOLUTIONS

N/R/W Values

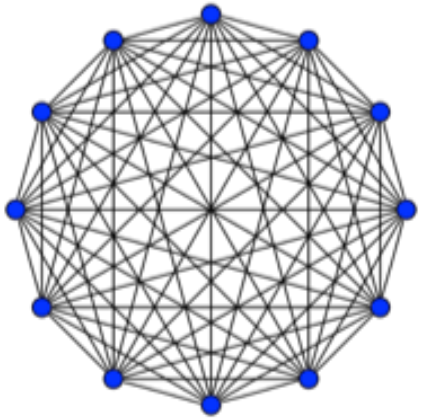


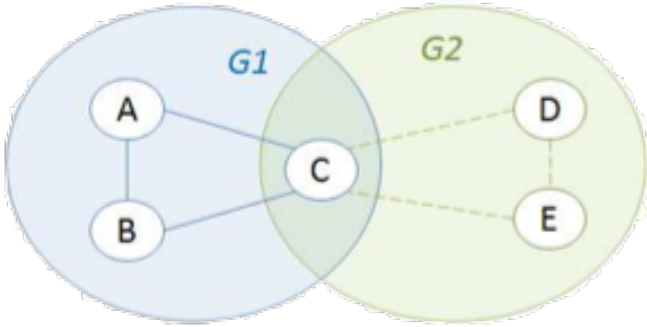
N/R/W Values



Clusters and SD Erlang

- Two major issues
  - Fully connected clusters
  - Explicit process placement
- Scalable Distributed (SD) Erlang
  - Nodes grouping
  - Non-transitive connections
  - Implicit process placement
  - Part of the standard Erlang/OTP package
- New concepts introduced
  - Locality, Affinity and Distance





Erlang SOLUTIONS

Release Statement of Aims

"To scale the radical concurrency-oriented programming paradigm to build reliable general-purpose software, such as server-based systems, on massively parallel machines (10^5 cores)."

RELEASE

University of Kent

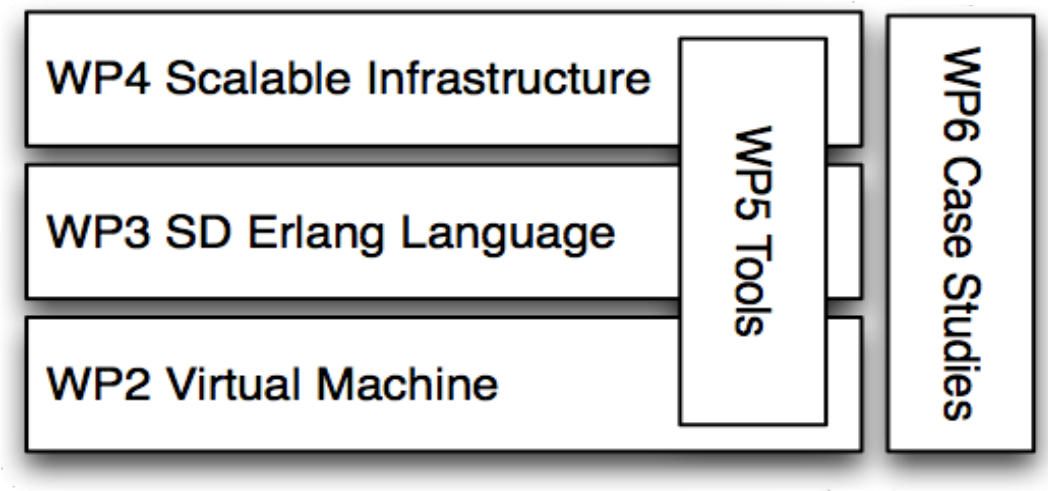
UPPSALA
UNIVERSITET

Erlang
SOLUTIONS

Release

"Limitations exist on all levels. You would not want an Erlang VM to run with 10^5 schedulers."

RELEASE



Erlang SOLUTIONS

Release

Push the responsibility for scalability from the programmer to the VM

Analyze performance and scalability

Identify bottlenecks and prioritize changes and extensions

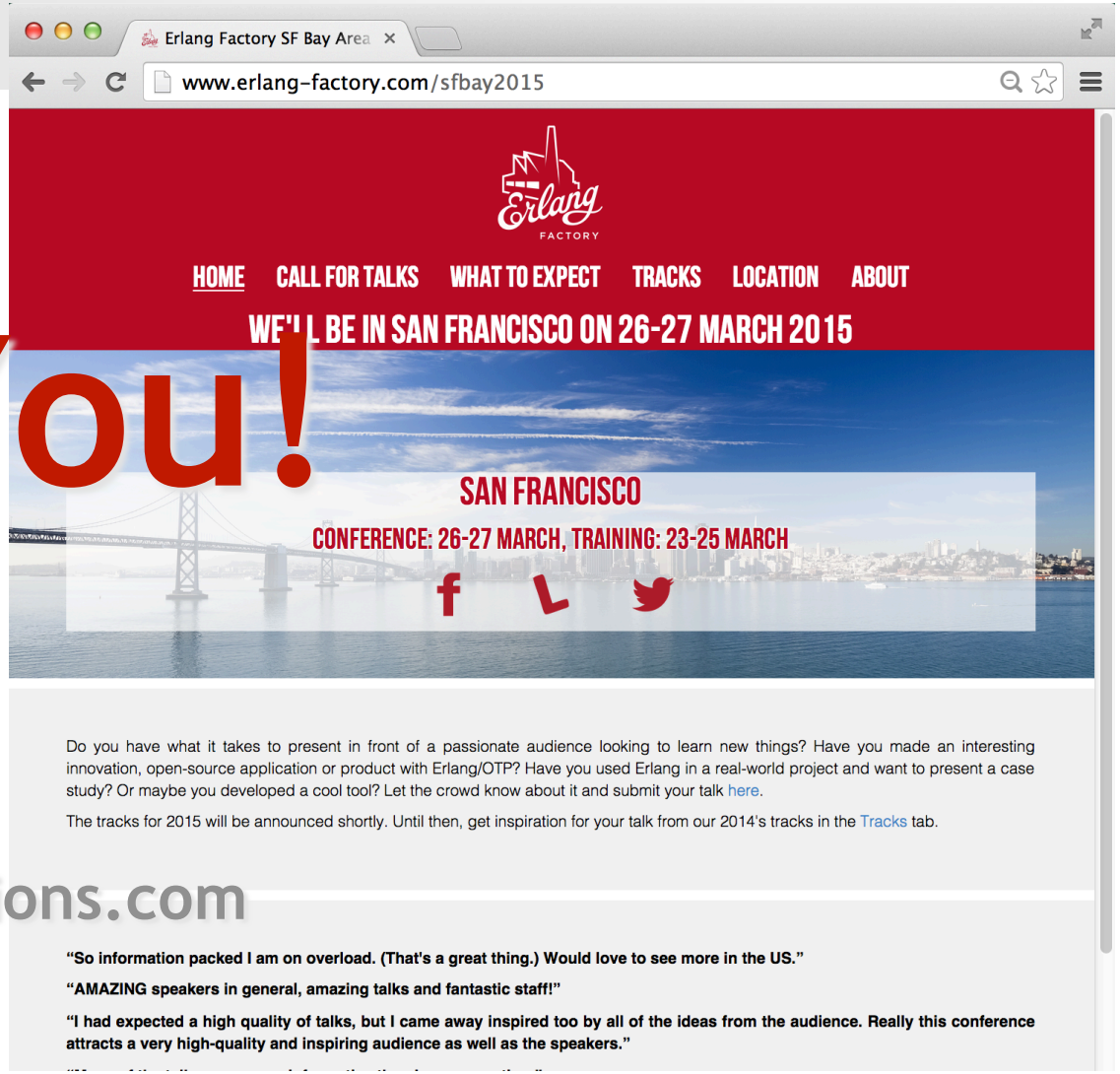
Tackle well-known scalability issues

Ets tables (shared global data structure)

Message passing, copying and frequently communicating processes

Erlang SOLUTIONS

Thank You!

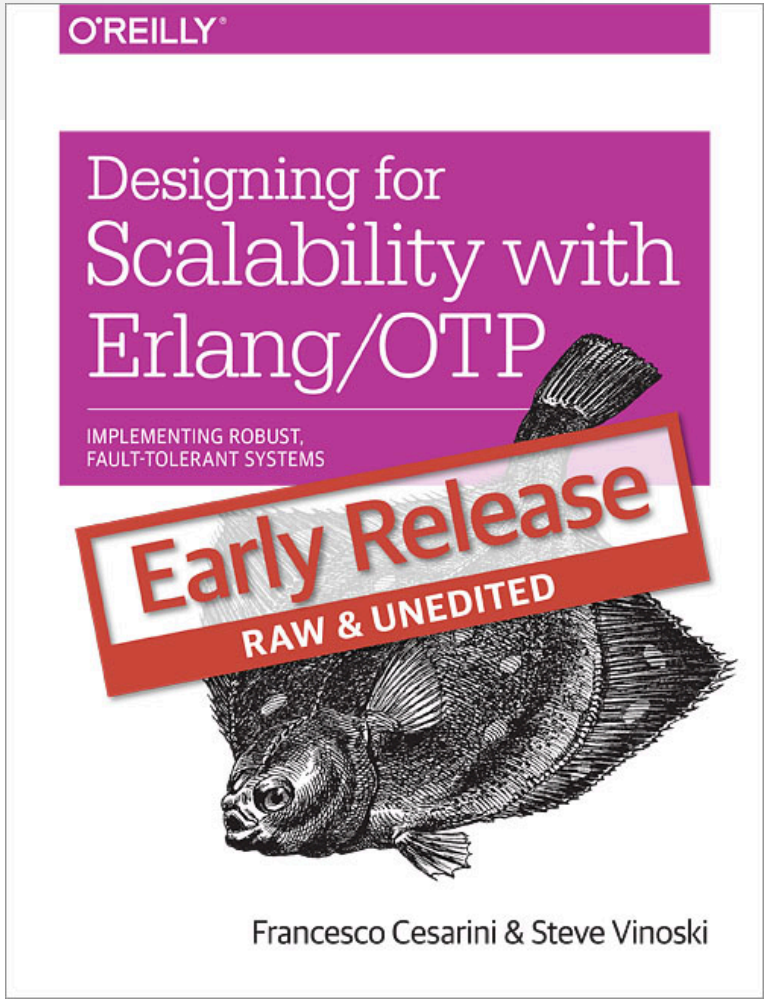


@francescoc
francesco@erlang-solutions.com

Erlang SOLUTIONS

Thank You!

@francescoc
francesco@erlang-solutions.com



Discount Code: ***authd***
50% off the Early Release
40% off the printed copy

goto; conference

Please

Remember to rate session

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