Erlang Multicore support

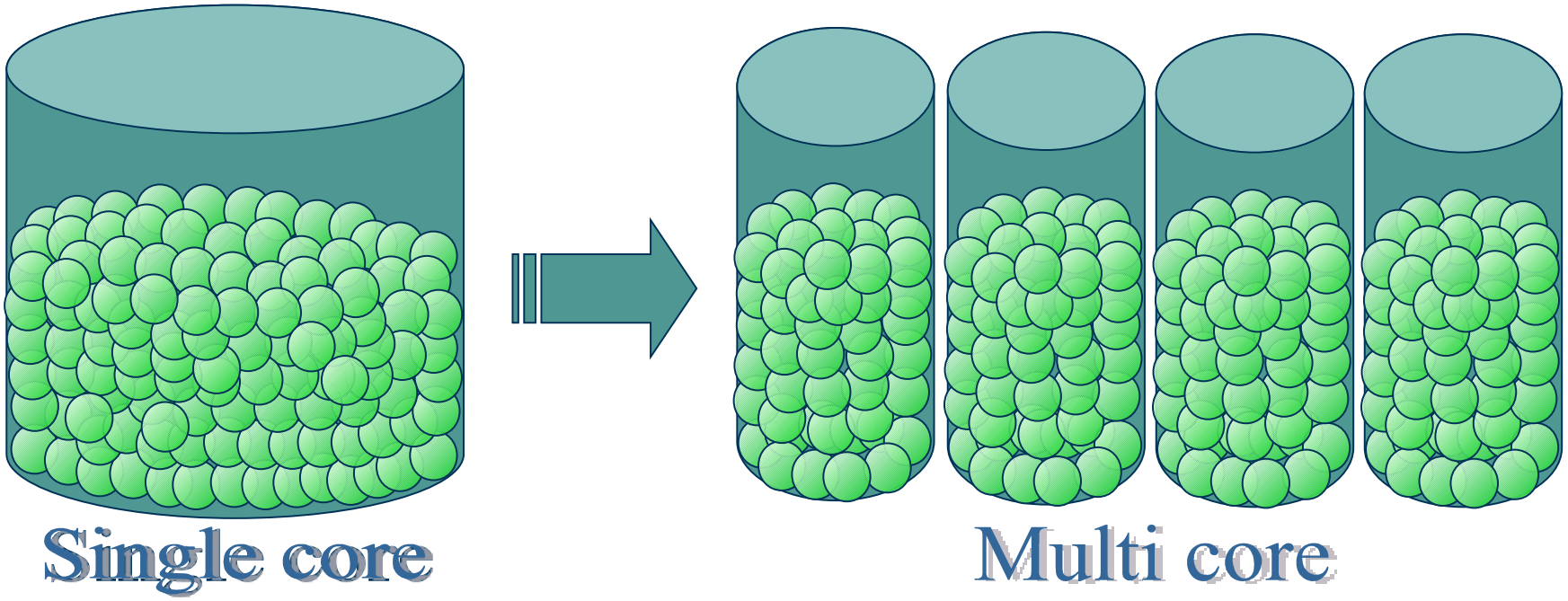
Behind the scenes

Erlang VM (BEAM) when we started

- Virtual register machine which scheduled light weight processes
  - One single process scheduler and one queue per priority level
  - Switching between I/O operations and process scheduling
- I/O drivers and “built in functions” (native functions) had exclusive access to the data structures
  - Network code
  - ETS tables
  - Process inspection etc

Perfect program for using multicore

- A lot of small units of execution
- The parallel mindset has created applications just waiting to be spread over several physical cores



Conversion steps

- Multiple schedulers
- Parallel I/O
- Parallel memory allocation
- Multiple run-queues and generally less global locking

Multiple schedulers

- Tools
  - Locking order and lock-checker
  - Ordinary test cases
  - Benchmarks (synthetic)
- Techniques
  - Own thread library (Uppsala University)
  - Lock tables and custom lock implementation for processes
  - Lots of conventional mutexes
- Result
  - One scheduler per logical core
- Insights
  - You will have to make memory/speed tradeoffs
  - Lock order enforcement is very helpful

Parallel I/O

- Tools
  - More simple benchmarks
  - Customer systems
  - Intuition (or – the problem was obvious…)
- Techniques
  - More fine granular locking
  - Locking on different levels depending on I/O driver implementation
  - Scheduling of I/O-operations
- Result
  - Real applications parallel…
- Insight
  - Doing things at the right time can vastly reduce complexity

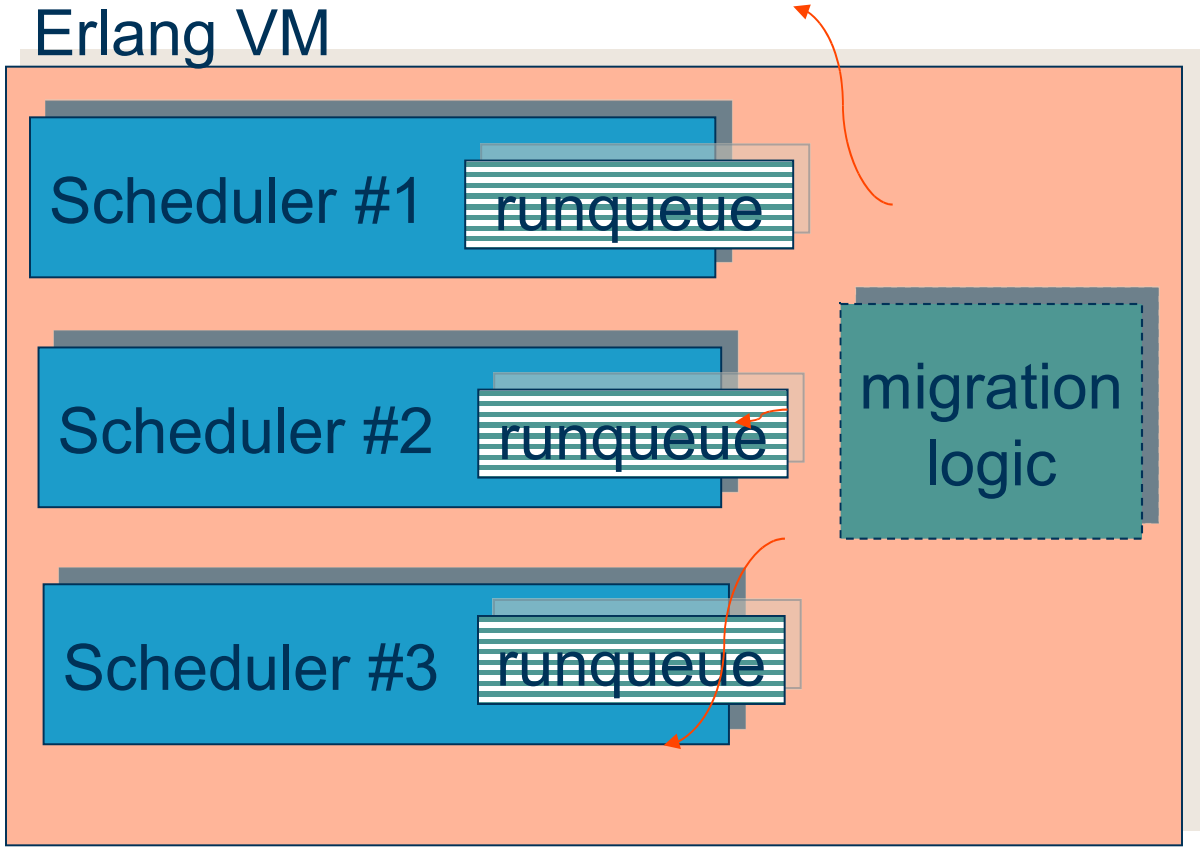
Multiple allocators

- Tools
  - Even more benchmarks
  - vTune (Intel-specific)
  - Thread profiler (Intel-specific)
- Techniques
  - Each scheduler has it's own instance of memory allocators
  - The "malloc" implementation was already our own
  - Locks are still needed as one scheduler might free another schedulers memory
- Result
  - Greatly improved performance for CPU intense applications
- Insight
  - Not only execution has to be distributed over cores

Multiple run-queues and generally less global locking

- Tools
  - Custom lock counting implemented (not cpu-specific)
  - More massive multicore CPU's to test on (Tilera, Nehalem)
  - More customer code from more projects
- Techniques
  - Distributing data over the schedulers
  - Load balancing at certain points
  - More fine granular locking (ETS Meta- and shared tables)
  - Reimplementation of distribution marshaling to remove need for sequential encode/decode
- Results
  - Far better performance on massive multicore systems
  - Nehalem performance great, but core2 still problematic
- Insight
  - No global lock will ever fail to create a bottleneck

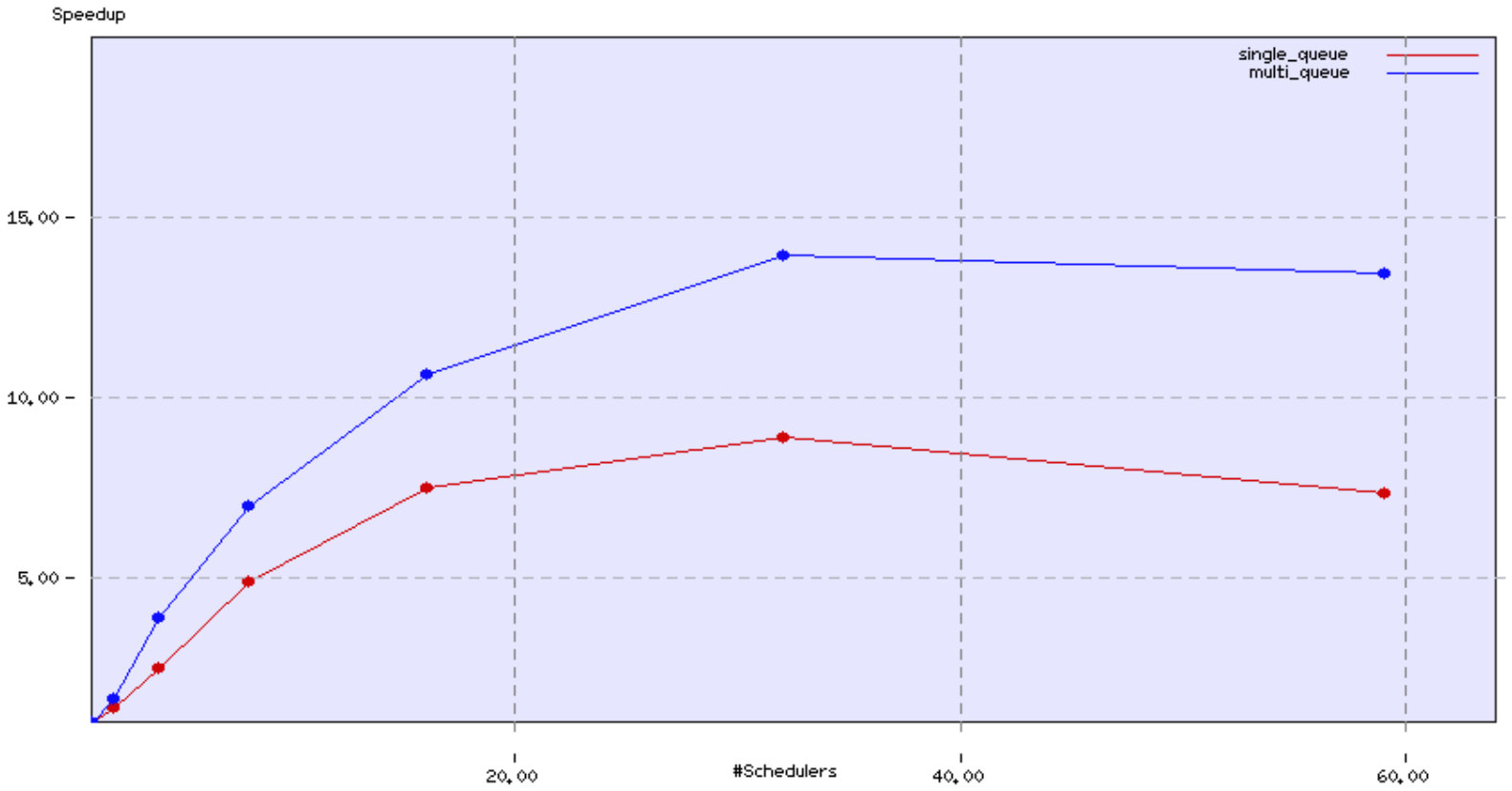
Multiple runq-ueues
Erlang SMP VM (R13)



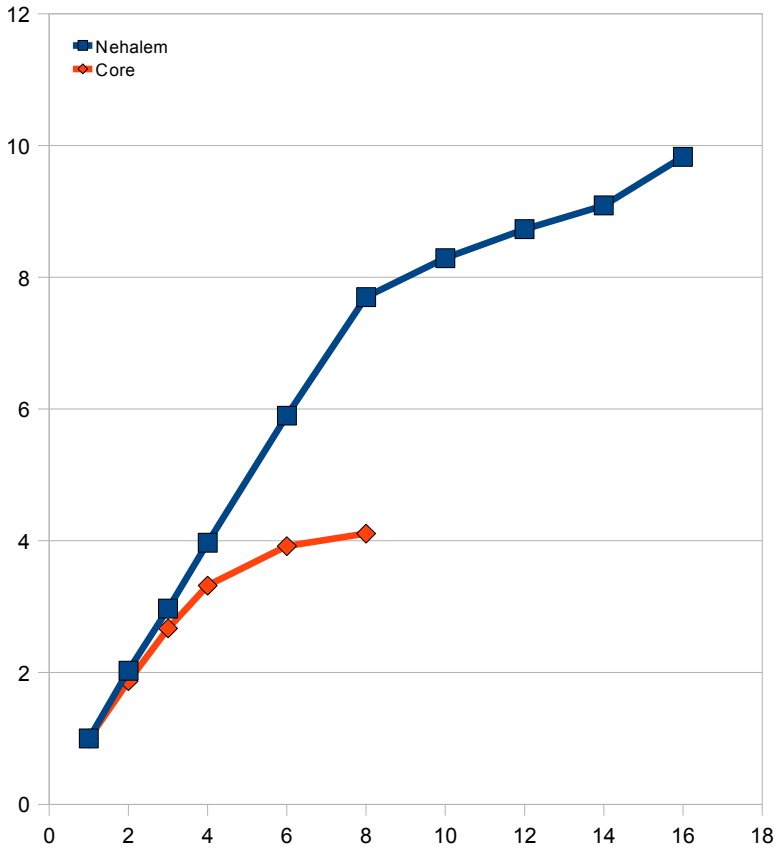
Migration logic

- Keep the schedulers equally loaded
- Load balancing after a specific amount of reductions
  - Calculate an average run-queue length
  - Setup migration paths
- Each scheduler migrates jobs until happy
- If a scheduler has suddenly no job, it starts stealing work
- If, at load-balancing, the logic detects to little work for the schedulers, some will be temporarily inactivated

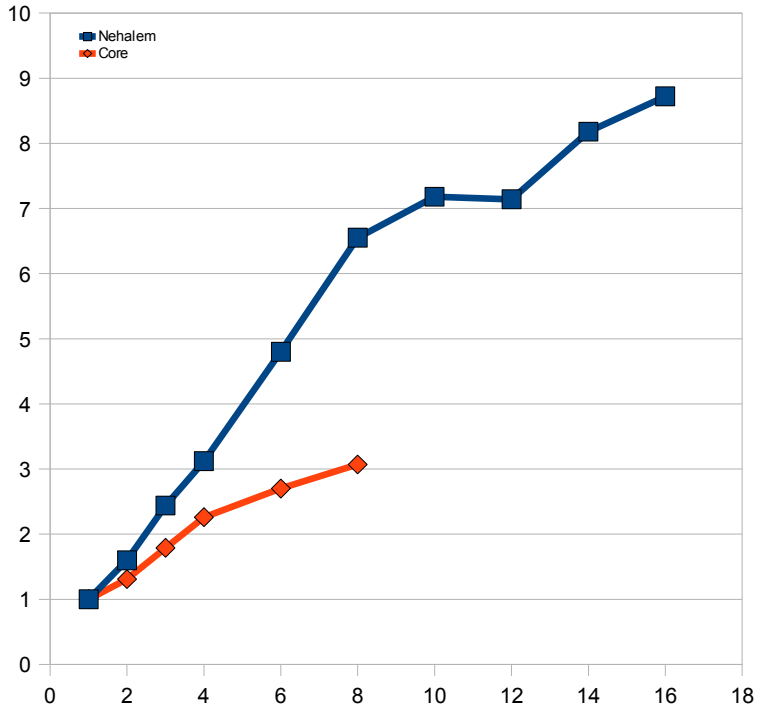
Example of performance gain w/ multiple run-queues in TilePro64



Comparing “Clovertown” Xeon E5310 to “Gainstown” Xeon X5570



Memory/CPU



Interprocess communication

Insights

- No global lock ever goes unpunished
- Data as well as execution has to be distributed over cores
  - Malloc and friends will be a bottleneck
- You will have to make memory/speed tradeoffs
- New architectures will give you both new challenges and performance boosts
  - Revise and rewrite as processors evolve
- Doing things (in the code) at the right time can reduce complexity as well as increase performance
- Take the time to use third party tools and to write your own.
- Work incrementally

Tools we've used

- Lock checker (implemented in VM) and strict locking order
- vTune and thread profiler
- oProfile
- Lock counter (implemented in VM)
- Acumem (www.acumem.com)
- Valgrind
- Benchmarks
  - Customers
  - Open Source
- Percept (Erlang application parallelism measurement tool)

What now?

- Non uniform memory access
  - Schedulers private memory near core
  - Distribute processes smarter, taking memory access into account
  - …
- Delayed deallocation to avoid allocator lock conflicts
  - Especially important for Core systems
- Developing our libraries
- Using less memory?
- More measuring, benchmarking, customer tests…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