OC4MC

OCaml for MultiCore

Deuxième réunion du GDR GPL/LTP

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project timeline

2008

June

September

2009

April

Now

Jane Street OCaml summer project

(pause)

Mathias' research project

continuing

broken implementations

numerous bug fixes

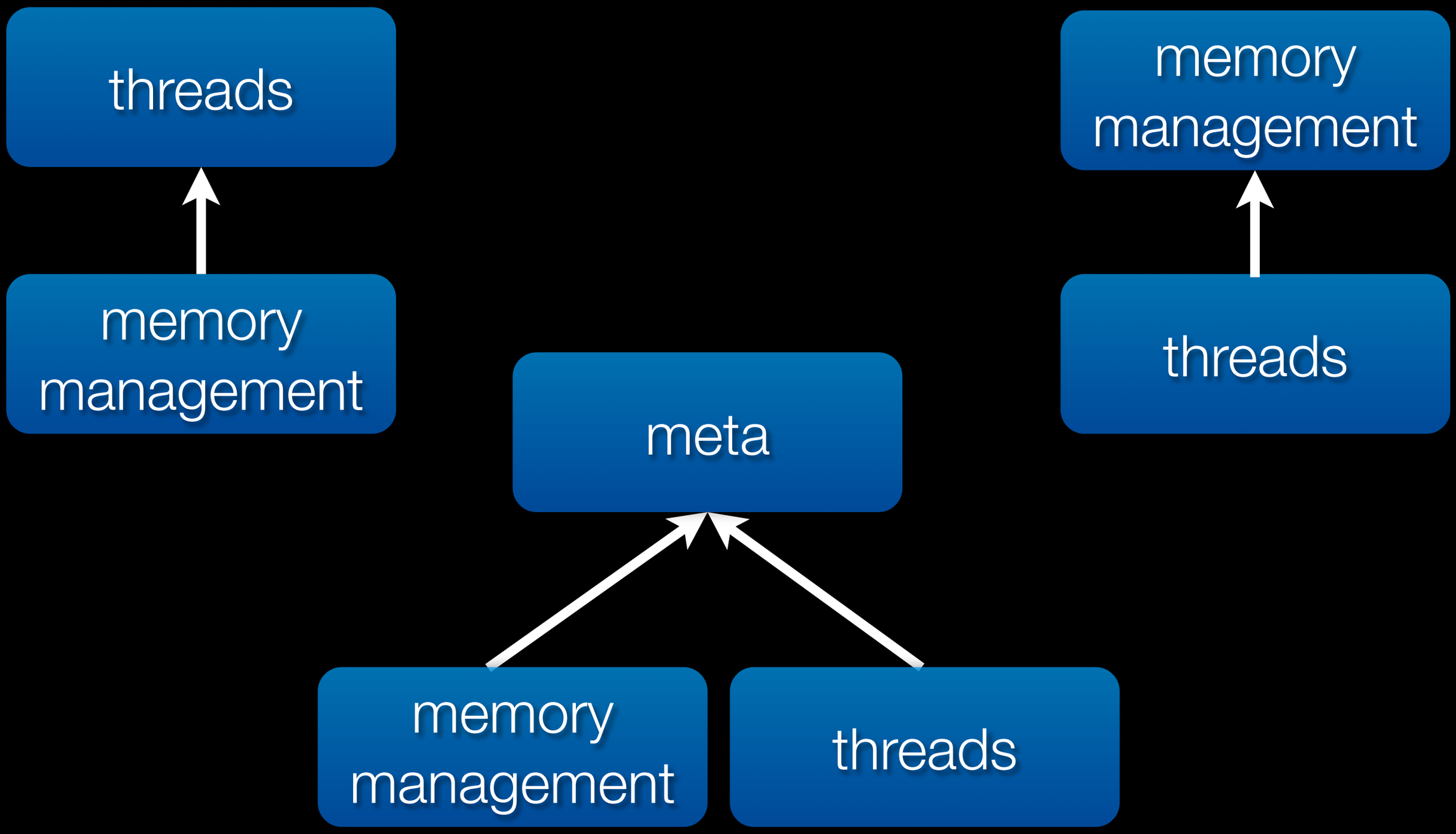
multithreading based multicore profit with OCaml

- (super light) preliminaries
- chapter 1 / OCaml & Parallelism
- chapter 2 / OCaml for MultiCore
- chapter 3 / Performance
- chapter 4 / Conclusion & Future Work

preliminaries

dependencies mess

dependencies



interdependencies

if there is a garbage collector and there are threads, then their implementations are probably interdependent

chapter 1

OCaml & Parallelism

(what a mess around)

multitask programming

join calculus
concurrent dataflow
cooperative threads
preemptive threads
ASM
cluster
CUDA
grid
Ada
(heavy) process
lo
OpenCL
C
p2p
Oz
SML
OCaml
Java
Concurrent ML
internet computing
JOCaml
Alice
Haskell
Join Java
Concurrent Haskell
MultiLisp
Scala
Clojure
PPE+SPEs
assembly tweaking
shared memory
message passing
CELL
CCS
SIMD GPU
MIMD CPU
π-calculus
NVIDIA GeForce GT130
Intel Core Quad
pict

(still the same mess)

multitask programming

Concurrent Haskell
JOCaml
Concurrent ML
Join Java
π-calculus
Alice
pict
CCS
Io
MultiLisp
Ada
Oz
OC4MC
OCaml
Haskell
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CELL
Intel Core Quad

some Caml history

cheap multicores

1985 1991 1996 today

Caml

Caml Light

Objective Caml

Objective Caml

- Functional-based multiparadigm language
- Distribution by INRIA
  - known for its efficiency
  - non-parallel concurrent threads

some

parallel threads issues

- runtime library support
- reentrance (beware of shared static variables)
- memory allocation/collection

addressing some

parallel threads issues

- runtime library support
  - reentrance (beware of shared static variables)
    - use (POSIX) `__thread` facility
    - transform to function parameters
    - refactoring
- memory allocation/collection

addressing some

parallel threads issues

- runtime library support
  - reentrance (beware of shared static variables)
- memory allocation/collection
  - look at the guts, be scared, run or make a choice
    - learn, understand, adapt
    - learn, remove parts & rewrite from scratch

INRIA OCAML

memory management

- **allocation**
  - `heap_ptr = heap_ptr - size(val)`
- **two-generation collection**
  - minor collection: stop&copy
  - major collection: incremental mark&sweep&compact

INRIA OCAML

garbage collection

young heap

Stop&Copy
survivors
to old heap

old heap

Mark&Sweep
+ compact

very efficient

generational

incremental

(runtime lib implementation in C code + asm)

chapter 2

OCaml for MultiCore

(influence of the) 


past experience

Pagano et al. (JFLA 2007, PADL 2008, ICFP 2009)

- alternative runtime lib implementation for software certification required by civil avionics norms
- memory management too hard to explain
  thus impossible to certify
- remove concurrency, marshalling, weak pointers, ...
- result: from 16 000 lines of C code to 4 500

addressing some

parallel threads issues

- runtime library support
  - reentrance (beware of shared static variables)
  - memory allocation/collection
    - look at the guts, be scared, run or make a choice
      - learn, understand, adapt
      - learn, remove parts & rewrite from scratch

and what about scheduling?

interdependencies

if the memory management implies moving values,
then it can stop a thread from accessing values...

OCaml for MultiCore

- **new memory management**
  - **stop** the world **&** two-generation **copy**
    - “inherited” mechanisms
      - stop at allocation, blocking operations
- **parallel threads**

OC4MC

Partial Collection

Stop&Copy

pages

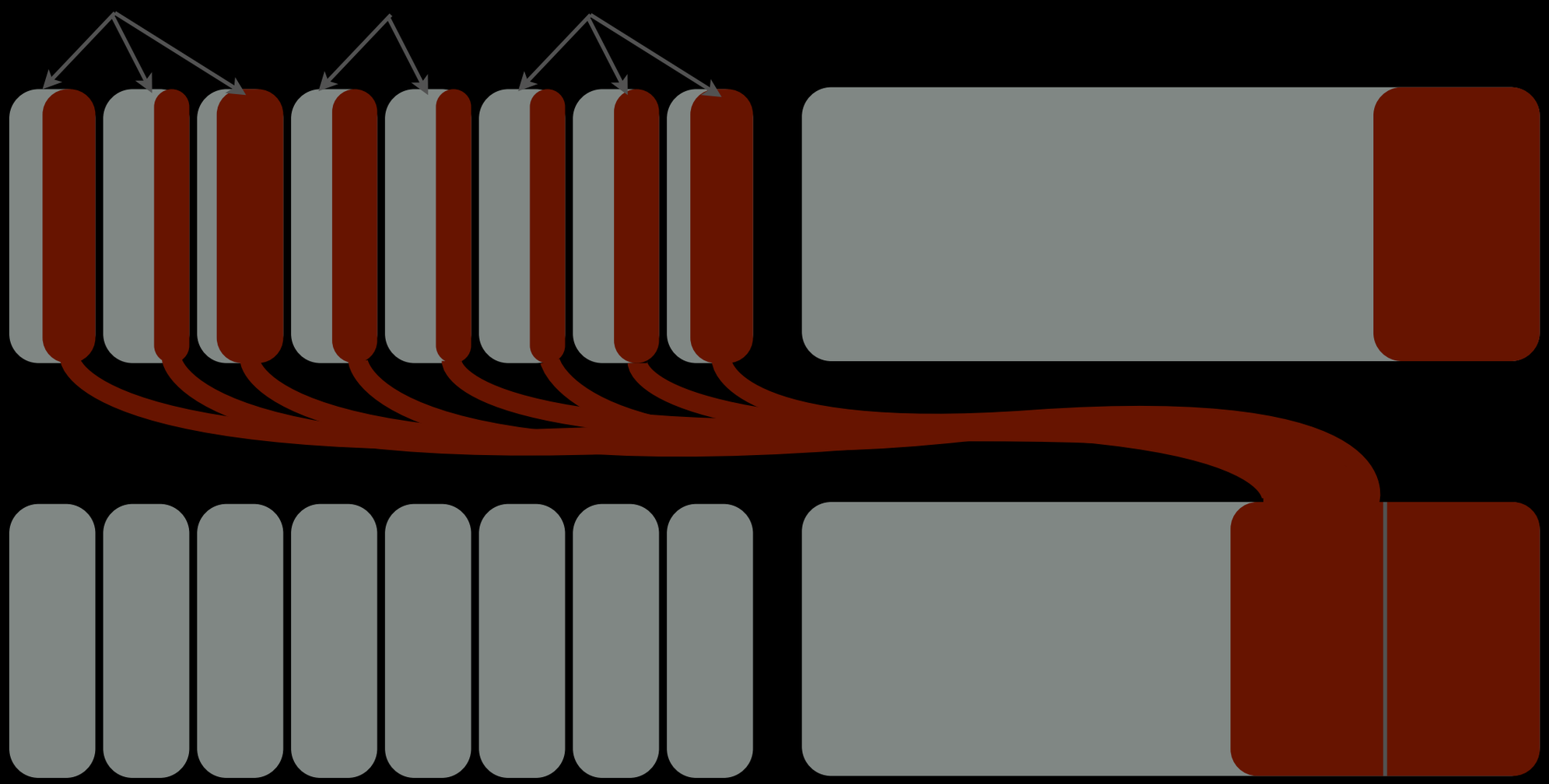
shared heap

thread 1 thread 2 thread 3

Before

Partial GC

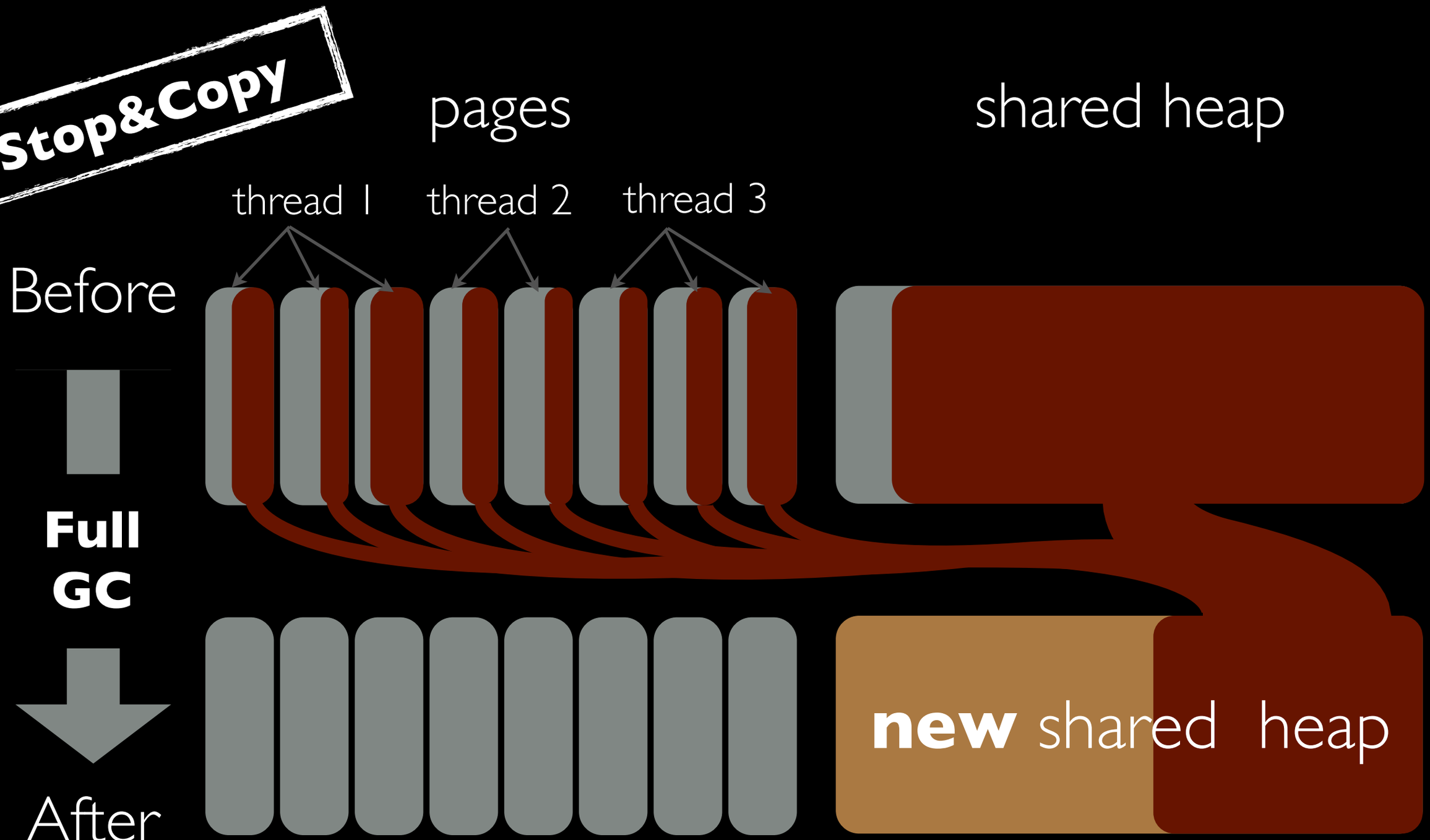
After



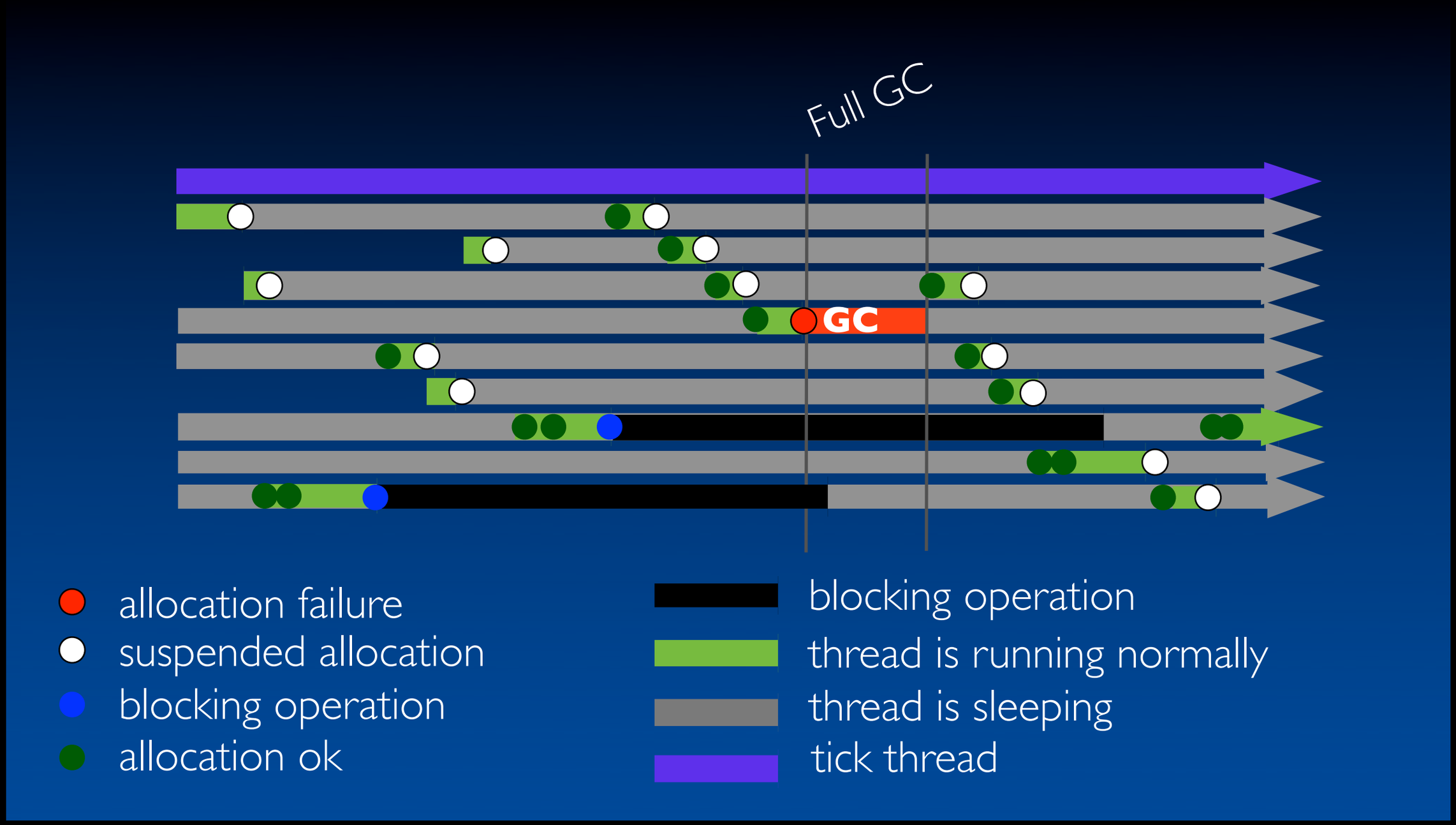
OC4MC

Full Collection

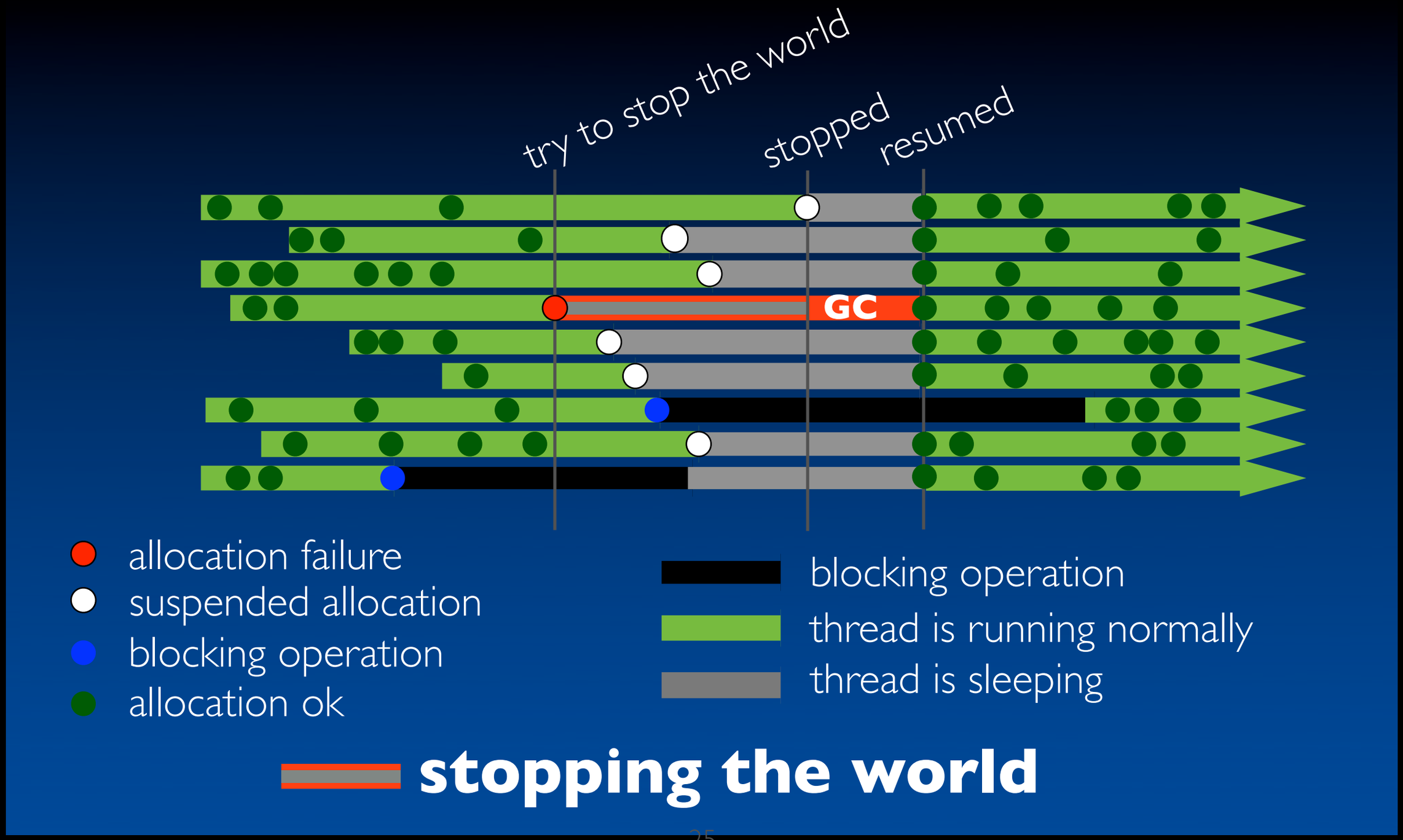
Stop&Copy



Execution Sample



Execution Sample



chapter 3

performance

Speedups

	O'Caml	**OC4MC**				
# of threads	1TH	1TH	2TH	4TH	8TH	16TH
Sieve	60s	64s	32s	16s	10s	9s
speedup	**1.06**	**1**	**2**	**4**	**6.4**	**7.11**
Matmult	15.5s	18.2s	9.5s	4.7s	2.5s	2.5s
speedup	**1.17**	**1**	**1.92**	**3.88**	**7.28**	**7.28**
Life	24.3s	24.7s	16.6s	13.7s	15.1s	15.2s
speedup	**1.02**	**1**	**1.49**	**1.80**	**1.64**	**1.62**

little number of threads

	O'Caml	**OC4MC**
Sieve CML-style	89s	59s
speedup	**1**	**1.50**

great number of threads

X86-64 Quad Core X 2
Virtual Machine : 7 active cores

Slowdowns

- GC algorithm kept as simple as possible
  - heap growth can slow down the program
    - very functional style (many short life objects) combined with some long life objects shows stop&copy weakness
- Predictable weakness

chapter 4

conclusion & future work

Conclusion

it’s working!

http://www.algo-prog.info/ocmc/

open source distribution

- Linux x86 64-bit
- Alternative multicore capable runtime library
  - memory manager replacement
  - thread library replacement
- Available as a patch for OCaml 3.10.2
  - **http://www.algo-prog.info/ocmc/**

Conclusion

- working multicore capable threads for OCaml
- proof of feasibility
- potential good performance

http://www.algo-prog.info/ocmc/

Related & Future Work

- OCaml concurrent/parallel extensions
  - what if they are used with OC4MC
- Use a limited number of threads by implementing abstractions on system threads
  - e.g. Parallel Concurrent ML
- Alternative GC algorithm

http://www.algo-prog.info/ocmc/