Multicore OCaml

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Concurrency and Parallelism

- Concurrency is for *writing programs*

  “my program handles 10,000 connections at once”

- Parallelism is for *performance*

  “my program makes use of 8 cores”

Concurrency in OCaml

- Good monadic concurrency libraries

  LWT and Async

  but monads are a bit awkward

- Direct-style threading library

  vmthreads and systhreads

  but neither is terribly efficient with many threads

Parallelism in OCaml

- Multiple processes with manual copying

  parmap, netmulticore, Async_parallel, ...

- Not much else.

  .... tumbleweed ...

Unify concurrency and parallelism?

- Concurrent programs are easily parallelised

  Should we use the same primitives?

- Java, C#, and others do

  But it's a bad idea :(

- At scale, death by context-switching

Fibers & Domains

- Fibers for concurrency

  Cheap to create, can have millions

- Domains for parallelism

  Expensive to create, have only a few

Concurrency Primitives

```
val spawn : (unit -> unit) -> unit


module MVar : sig
  type 'a t
  val create : unit -> 'a t
  val take : 'a t -> 'a
  val put : 'a t -> 'a -> unit
end
```

Higher-level concurrency

```
let async (f : unit -> 'a) : unit -> 'a =
  let m = MVar.create () in
  spawn (fun _ -> MVar.put m (f ()));
  fun _ -> MVar.take m
```

Parallelism primitives

- Multiple “domains” run in parallel

  Fibers are balanced between domains

- Creating domains is heavyweight

  Generally done once at startup and left alone

- Per-domain minor heap, shared major heap

  Differences not visible to OCaml code

Implementing the system

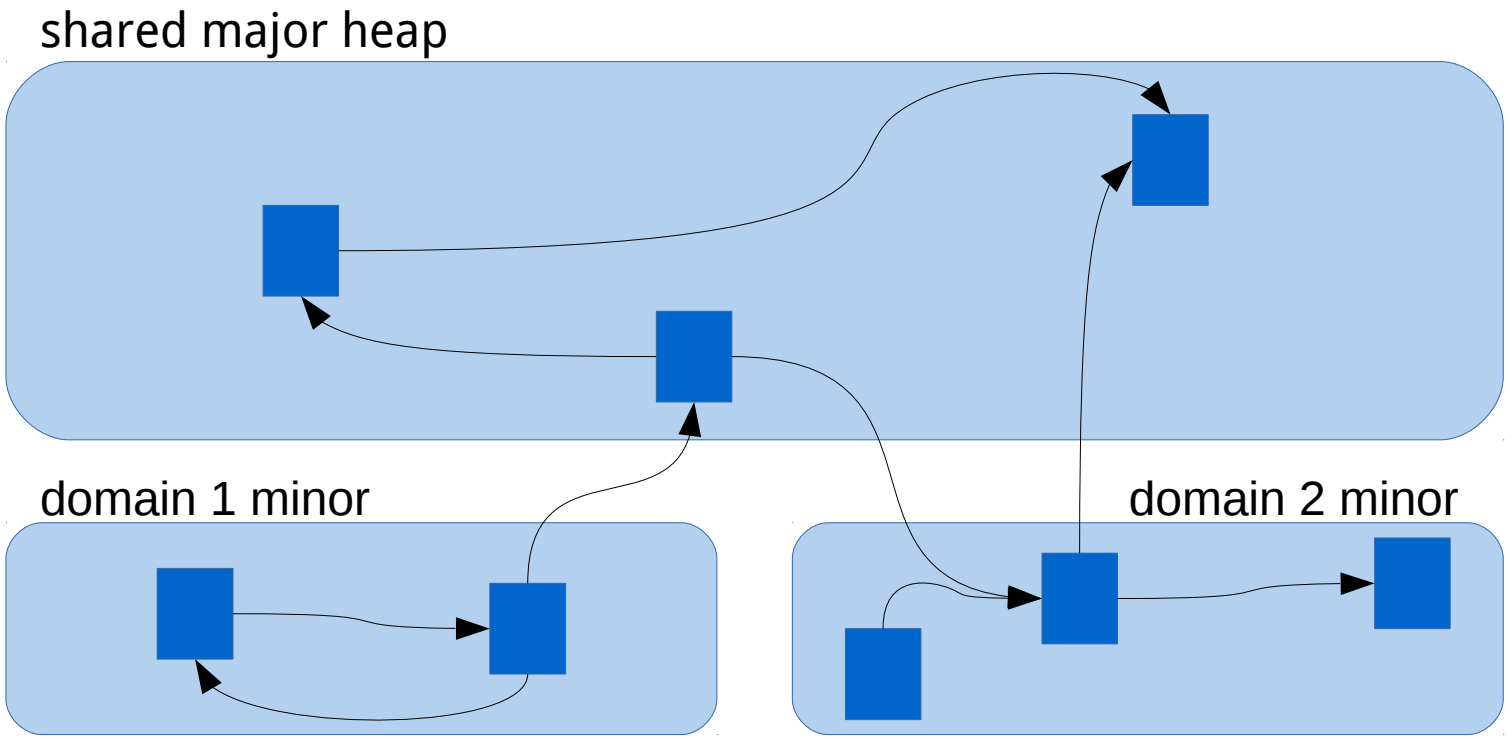
- OCaml is very fast for immutable data and functional programs

  We try to keep its behaviour unchanged

- Mutability is more complicated in a multithreaded system

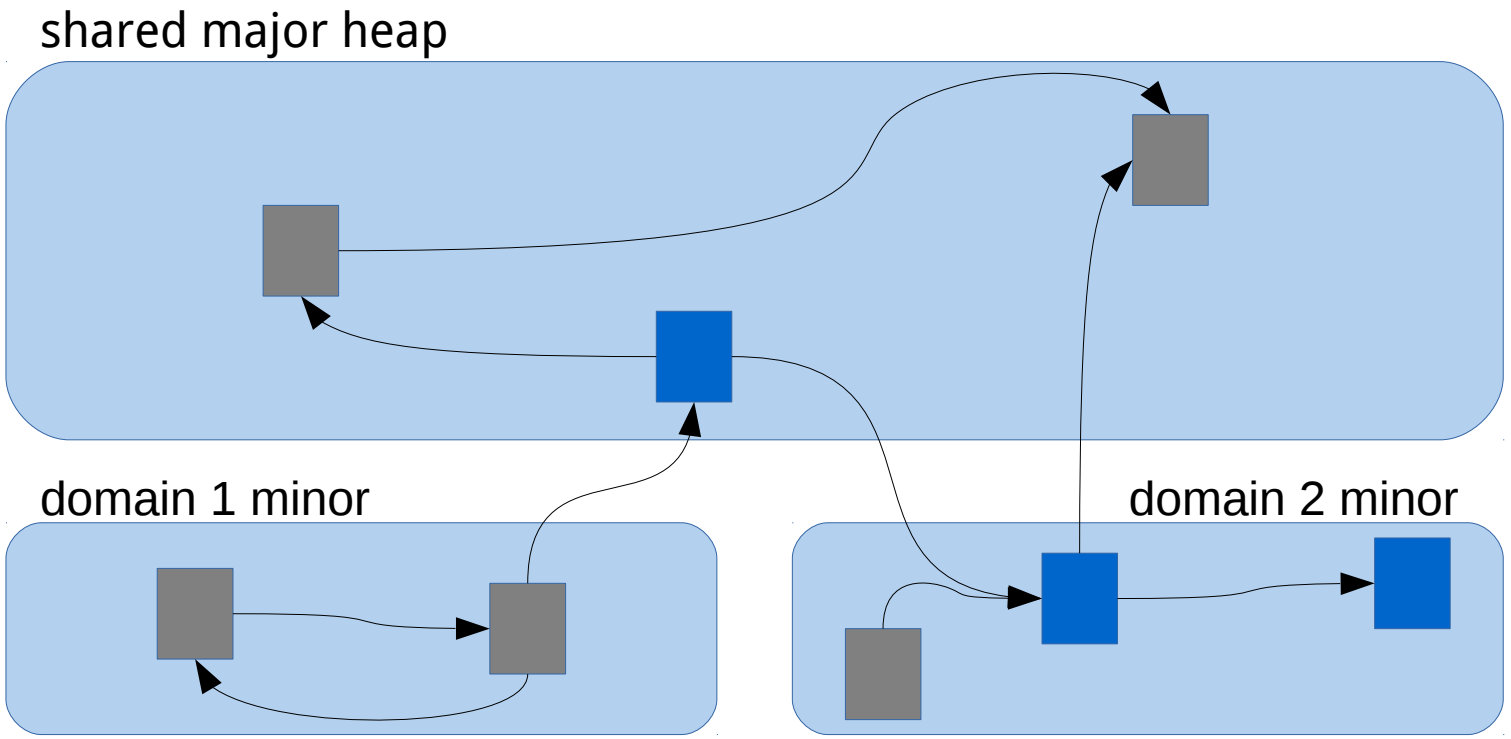
- We use a descendant of the Doligez-Leroy collector from Concurrent Caml Light

Private minor heaps



- Each domain has a private minor heap
  - No pointers between minor heaps

Private minor heaps



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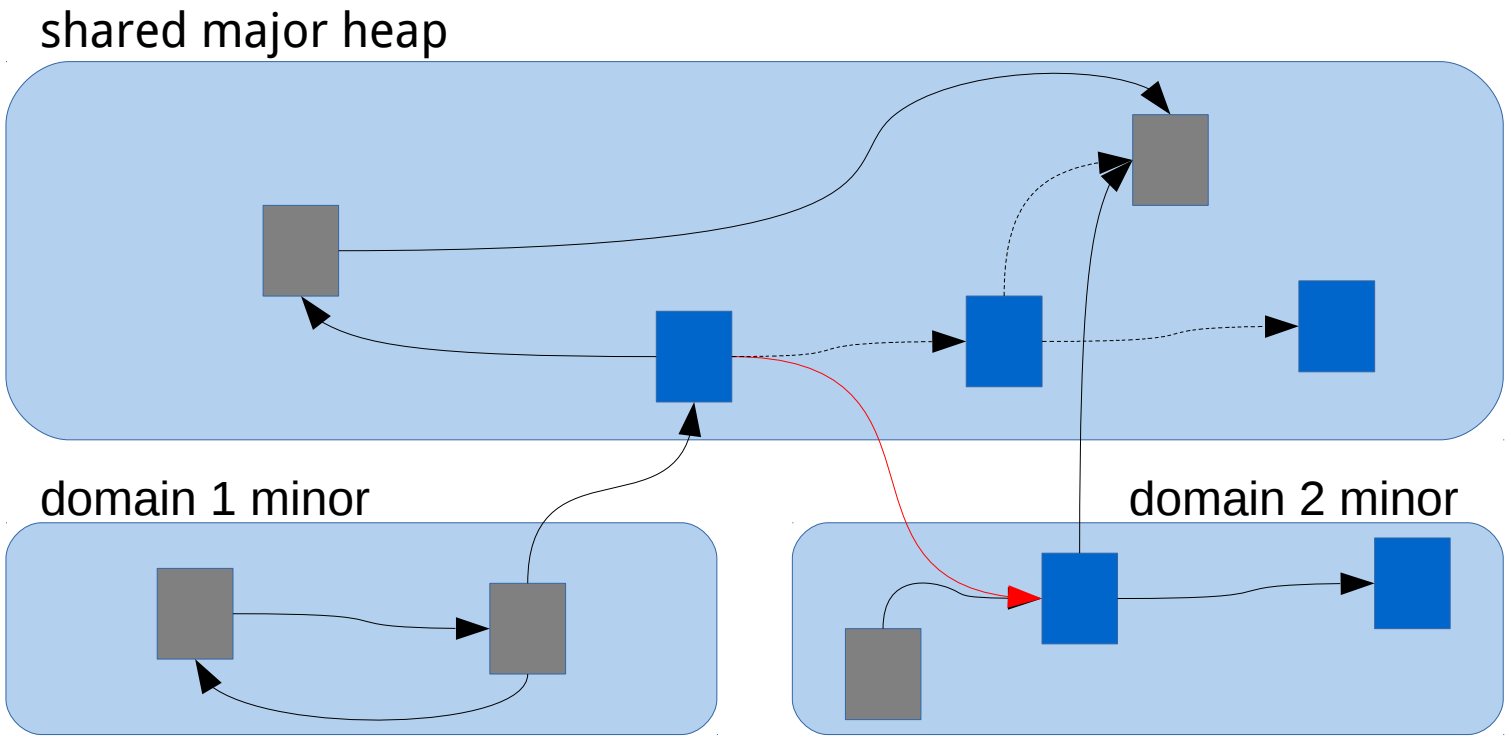
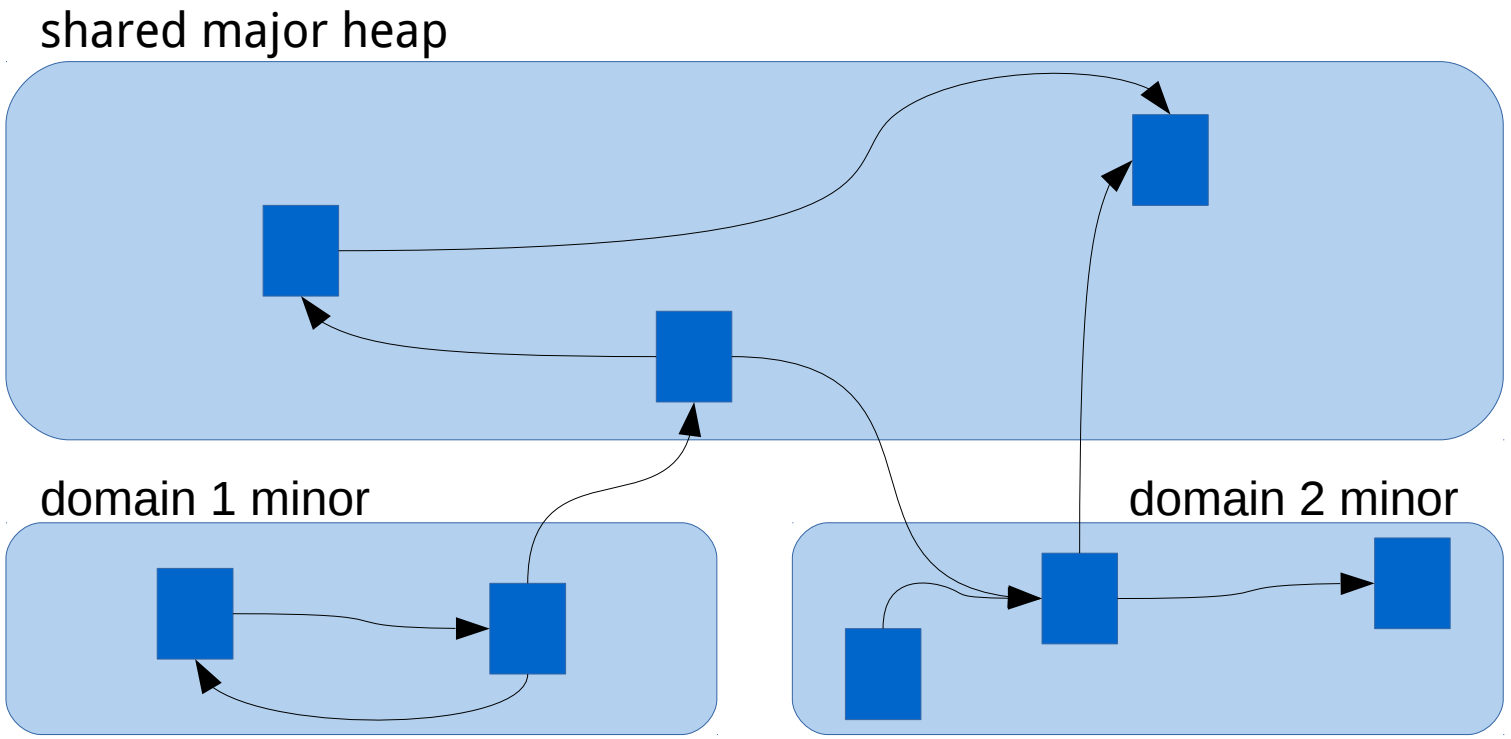
Barriers and faults



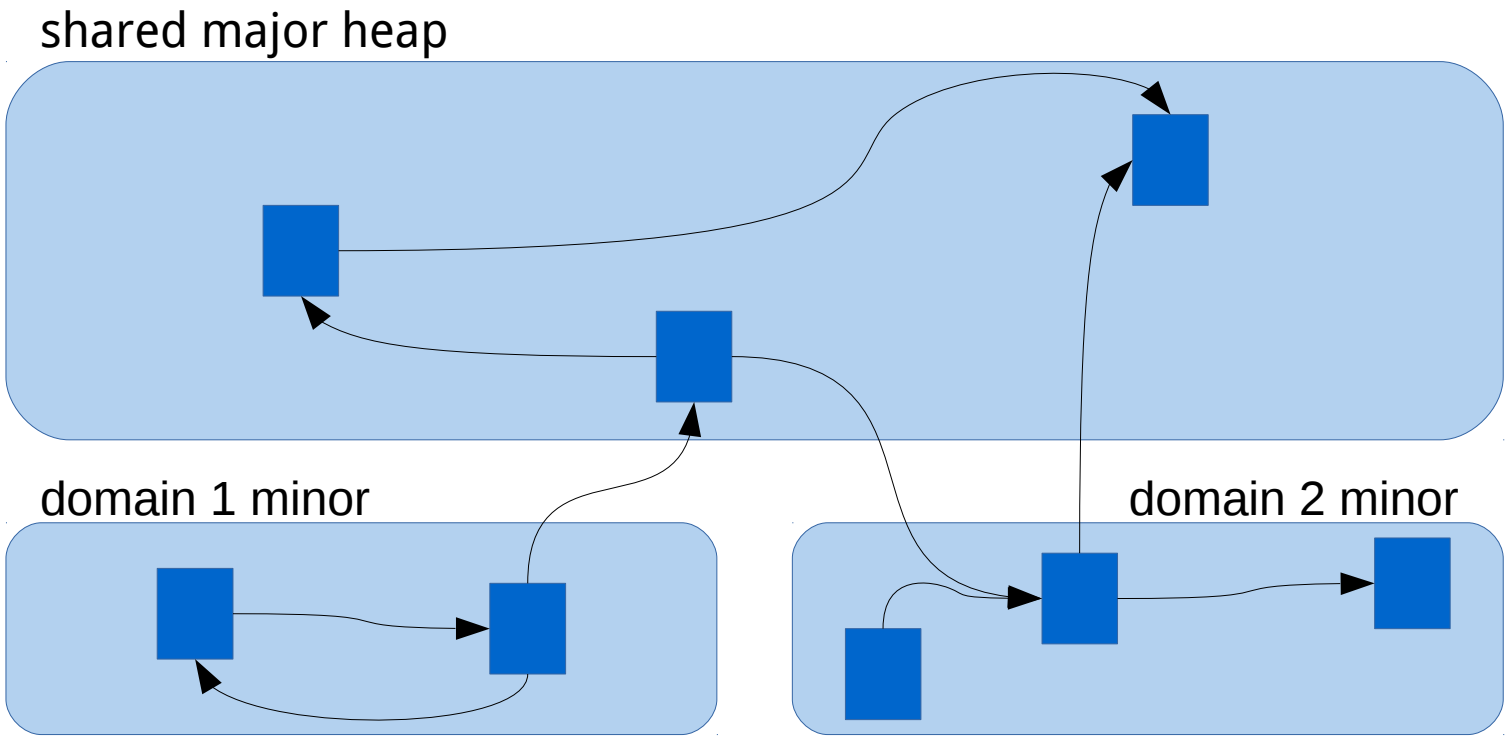
- Upon access to a foreign heap, a fault occurs
  - Creates a shared copy of reachable objects

Collecting the minor heaps



- Completely independent minor collections
  - Almost unmodified minor collector

Collecting the shared heap



- Mostly-concurrent parallel collector (VCGC)

  Requires synchronising domains once per cycle

Mostly-concurrent collection

- Domains race to mark reachable objects

  Some objects can be marked more than once

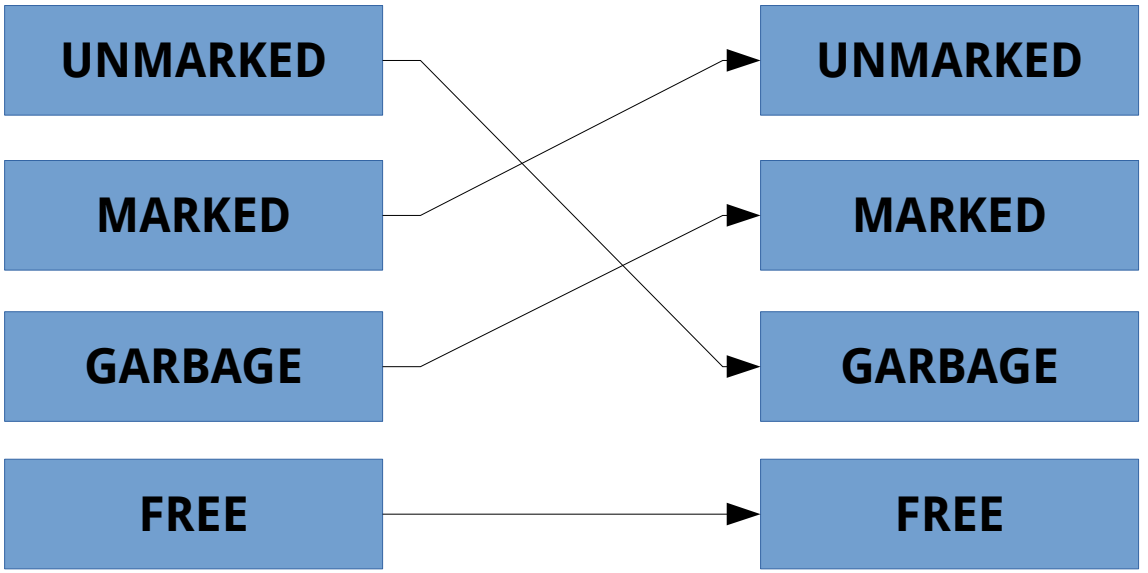
- Domains sweep separate parts of the heap

  Sweeping need not precede marking

Shared collector cycles

- Domains verify marking and remap GC bits

  Requires synchronising all domains, but there aren't many



Domains in `caml_enter_blocking_section` do not participate

C API

- Some minor changes (`sed` can fix most)

  ```
  caml_modify(&Field(x,i), y)
  ```

  becomes

  ```
  caml_modify_field(x, i, y)
  ```

- Same atomicity guarantees as current GC

- caml_{enter,leave}_blocking_section: does something different, has the same usage

Current Status

- Bootstraps, plays nicely with OPAM
  - Branched off slightly before 4.02, no camlp4 right now
- GC needs testing, tuning and benchmarking
  - GC policy is atrocious at the moment
- Bytecode only, and some features broken
  - Weak references, finalisers and lazy values need work

Questions?

github.com/stedolan/ocaml

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