Multicore OCaml

Прекрасный OCaml будущего

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Evrone.com

FPure

~$ wtf OCaml

- FP (multiparadigmal)
- Strict
- ML
- DOCS
- Quick start
- FAST code
- Native 4 all
- YEARS in production
- Toolz rule

```
let reader file_num =
  let name = Printf.sprintf "files/%d.dat" file_num in
  let descr = Unix.openfile name [O_RDONLY] 0o640 in
  let stream = Unix.in_channel_of_descr descr
               |> Stream.of_channel
  in
  let rec read_char stream n =
    match Stream.peek stream with
    | None -> n
    | _    ->
       Stream.junk stream;
       read_char stream (n + 1)
  in
  let nchars = read_char stream 0 in
  Unix.close descr;
  (name, nchars)
```

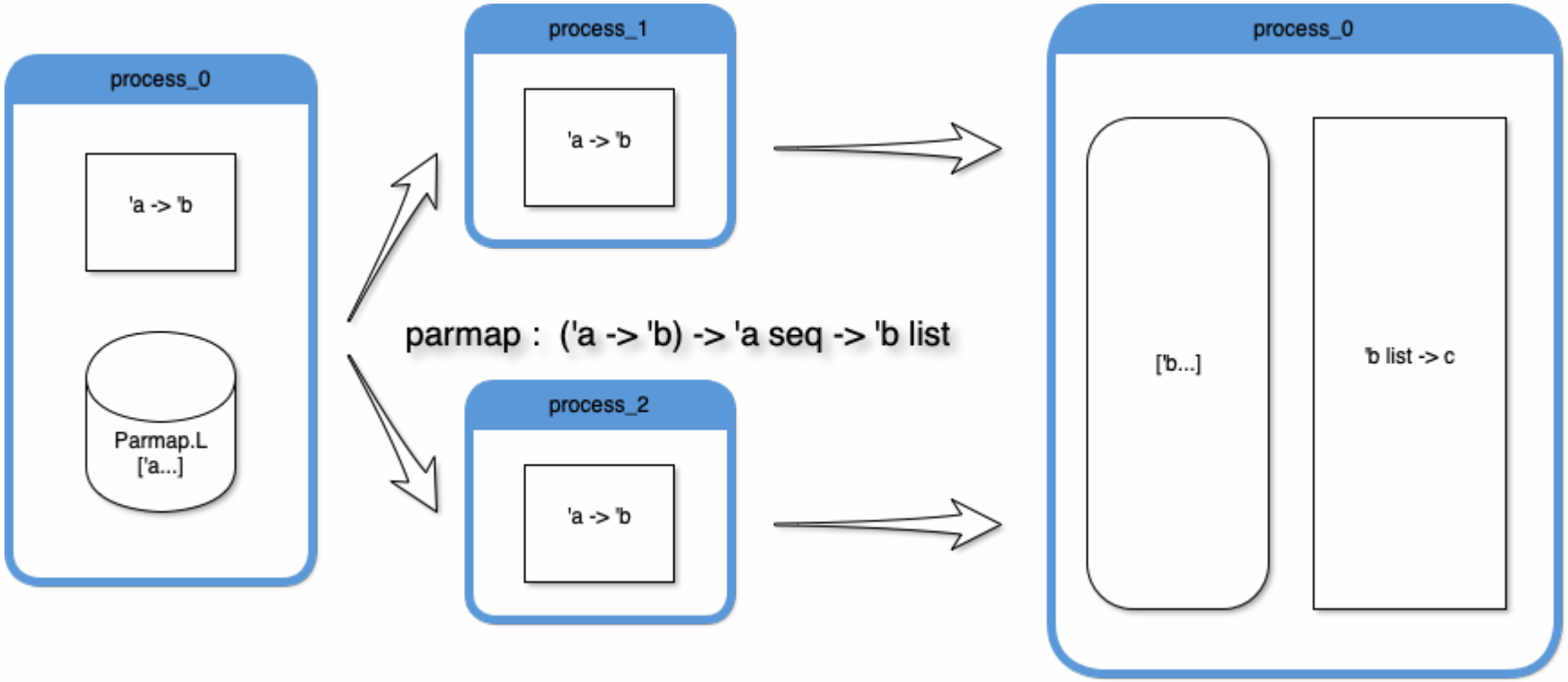
OCaml parallelism at hand

Ye olde fork()

```
module Unix = sig
  (* ... *)
  val fork : unit -> int
  (* ... *)
end
(* use *)
match fork () with
| 0   -> child_code ()
| pid -> parent_code pid
```

OCaml parallelism at hand

```
~$ opam install parmap
```



OCaml parallelism at hand

```
let num_files = 10

let reader file_num =
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  let rec read_char stream n =
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       Stream.junk stream;
       read_char stream (n + 1)
  in
  let nchars = read_char stream 0 in
  Unix.close descr;
  (name, nchars)

let run_readers_for num =
  Printf.printf "Starting %d workers\n" num;
  let ids = List.init num (fun i -> i + 1) in
  let results = Parmap.parmap ~ncores:num_files reader (Parmap.L ids) in
  List.iter (fun (name, n) -> Printf.printf "%s\t=> %d chars\n" name n) results

let () =
  run_readers_for num_files
```

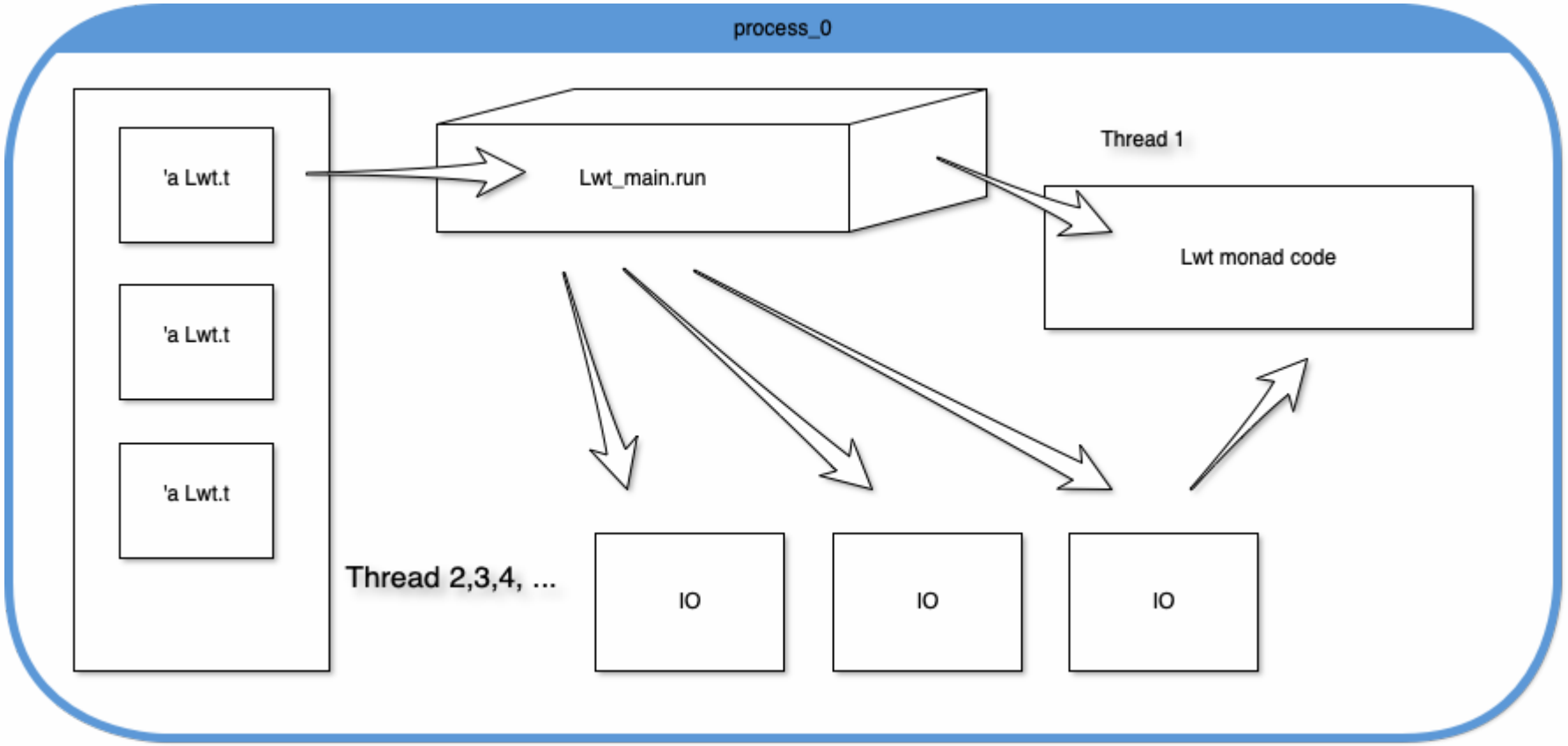
OCaml concurrency at hand

Monadic concurrency libs:

- `Async` by Janestreet
- `Lwt` by Ocsigen

OCaml concurrency at hand

```
~$ opam install lwt
```



OCaml concurrency at hand

```
let num_files = 10

let reader file_num =
  let name = Printf.sprintf "files/%d.dat" file_num in
  let stream = Lwt_io.chars_of_file name in
  let rec read_char stream n =
    match%lwt Lwt_stream.get stream with
    | None -> Lwt.return (name, n)
    | _    -> read_char stream (n + 1)
  in
  read_char stream 0

let collect_results =
  let rec append_to_ready ready pending =
    let%lwt (ready', pending') = pending in
    let ready'' = List.append ready ready' in
    match List.length pending' with
    | 0 -> Lwt.return ready''
    | _ -> Lwt.nchoose_split pending'
           |> append_to_ready ready''
  in
  append_to_ready []
```

OCaml concurrency at hand

```
let run_readers_for num =
  let%lwt () = Lwt_io.printlf "Starting %d workers" num in
  List.init num (fun i -> i + 1)
  |> List.map reader
  |> Lwt.nchoose_split
  |> collect_results

let () =
  run_readers_for num_files
  |> Lwt_main.run
  |> List.iter (fun (name, nchars) -> Printf.printf "%s\t=> %d chars\n" name nchars)
```

OCaml threads???

> The threads library is implemented by time-sharing on a single processor. It will not take advantage of multi-processor machines. Using this library will therefore never make programs run faster. However, many programs are easier to write when structured as several communicating processes.

Manual, The

> Currently, threading is supported in OCaml via the global interpreter lock (GIL), but this prohibits multiple threads running OCaml code at any one time.

Ocamllabs.io

~$ whois Multicore OCaml

OCaml Labs // ocamllabs.io // U. of Cambridge & Jane Street

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OCaml Labs // ocamllabs.io // U. of Cambridge & Jane Street

KC Sivaramakrishnan, PhD // @kayceesrk // IIT Madras

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  - Domains & fibers
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- Language
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  - Utility libs (e.g. Reagents)
- IRL code
  - (* WIP *)

Memory model

All about `ref`s

```
1. let r = ref 0 in
2. let a = !r in
3. r := 1
4. let b = !r in
5. let c = !r in
    ...
```

Memory model

Atomics

thread 1:

```
1. message := 42
2. flag := true
```

thread 2:

```
3. let seen = !flag in
4. let value = !message in
5. if seen then print_int value;
```

Memory model

Atomics

thread 1:

```
1. message := 42
2. flag := true
```

thread 2:

```
3. let seen = !flag in
4. let value = !message in
5. if seen then print_int value;
```

thread 1:

```
1. message := 42
2. Atomic.set flag true
```

thread 2:

```
3. let seen = Atomic.get flag in
4. let value = !message in
5. if seen then print_int value;
```

Memory model

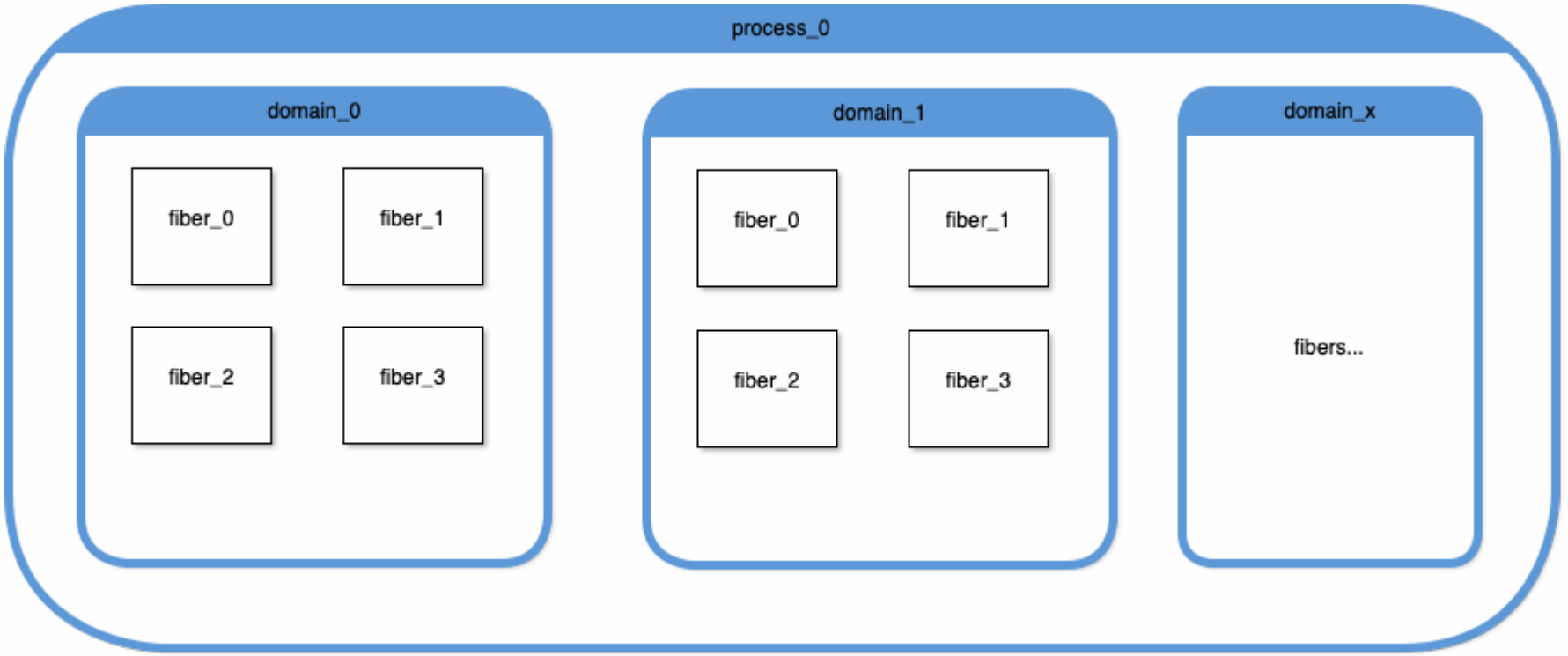
Atomic CAS (thanks KC)

```
module CAS : sig
  val cas : 'a ref -> expect:'a -> update:'a -> bool
end = struct

(* atomically... *)
let cas r ~expect ~update =
  if !r = expect then
  (r:= update; true)
  else false
end
```

Domains, fibers and GC

- Fibers: concurrency // "green threads"
- Domains: parallelism // maps to k. threads / CPU cores



Domains, fibers and GC

GC:

1. Generational (fibers/mutations, etc)
2. Independent minor GC
3. Mostly concurrent M&S major GC
4. Chalenges: performance & safety

Read: "A deep dive into Multicore OCaml garbage collector" by KC

Algebraic Effects

```
type 'a _promise =
  Waiting of ('a,unit) continuation list
| Done of 'a

type 'a promise = 'a _promise ref

effect Async : (unit -> 'a) -> 'a promise
let async f = perform (Async f)

effect Yield : unit
let yield () = perform Yield

effect Await : 'a promise -> 'a
let await p = perform (Await p)
```

```
let run main =
  let rec fork : 'a. 'a promise -> (unit -> 'a) -> uni
    fun pr main ->
      match main () with
      | v -> failwith "Value case not implemented"
      | effect (Async f) k ->
          failwith "Async not implemented"
      | effect Yield k ->
          enqueue (continue k);
          dequeue ()
      | effect (Await p) k ->
          begin match !p with
          | Done v -> continue k v
          | Waiting l -> failwith "Await.Waiting not i
          end
  in
  fork (ref (Waiting [])) main
```

Algebraic Effects

Continuations:

- => Fibers
- Linear (one-shot) / 'Linear types' via exceptions
- Heap-allocated stacks
- Modular vs monadic code
- `ocamllabs/ocaml-effects-tutorial`

Reagents

Reagents

- ... are from Scala

  Aaron Turon et al., 2012

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  esp. lock-free comms

- ... are Atomic

  with shared memory

- ... are Functions

  composable

Reagents

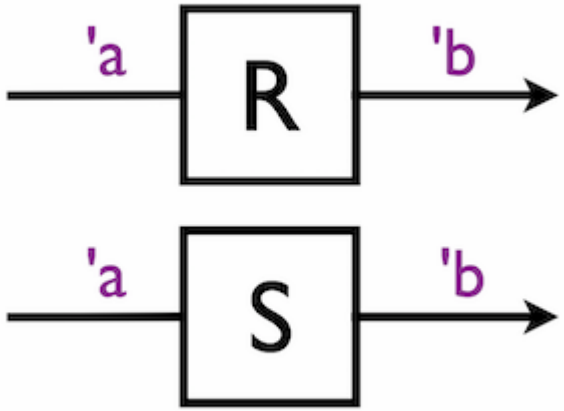
Dining Philosophers

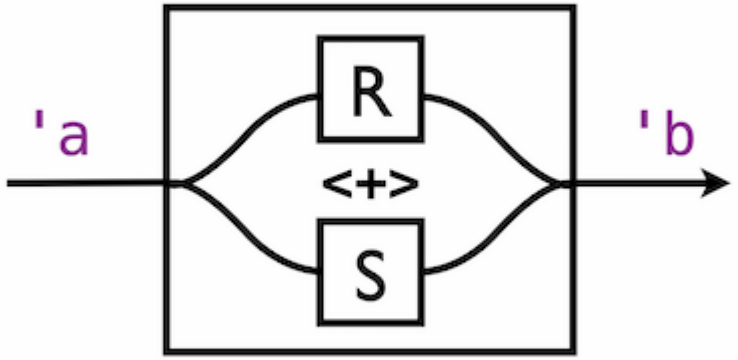
```
let (num_philosophers, num_rounds) = ...

...

module S = Sched_ws.Make (
  struct
    let num_domains = num_philosophers
    let is_affine = true
  end
)

module Reagents = Reagents.Make (S)
open Reagents
open Channel

...

type fork =
  {drop : (unit,unit) endpoint;
   take : (unit,unit) endpoint}
```

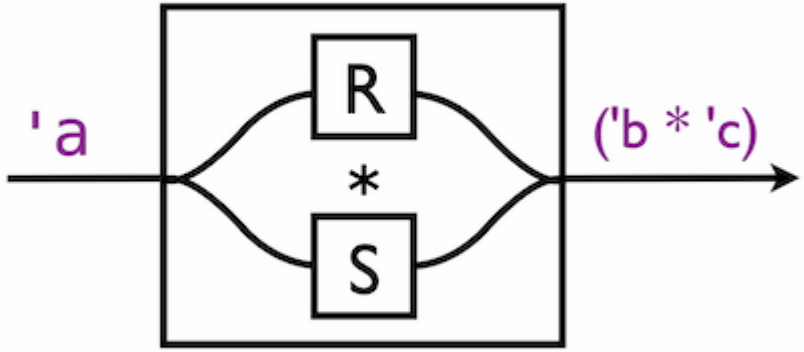
```
let drop f = swap f.drop
let take f = swap f.take

let eat l_fork r_fork =
  ignore @@ run (take l_fork <*> take r_fork) ();
  S.fork @@ run (drop l_fork);
  S.fork @@ run (drop r_fork)
```

Reagents

Combinators







History

- Jan 2014: Initiated by Stephen Dolan and Leo White
- Jan 2015: KC joins the project at OCaml Labs
- Sep 2015: Effect handlers @ OCaml workshop
- Jan 2016: Native code backend for Amd64 on Linux and OSX
- Jun 2016: Multicore rebased to 4.02.2 from 4.00.0
- Sep 2016: Reagents library, Multicore backend for Links @ OCaml workshop
- Apr 2017: ARM64 backend
- Sep 2017: Memory model proposal @ OCaml workshop
- Sep 2017: CPS translation for handlers @ FSCD
- Apr 2018: Multicore rebased to 4.06.1 (will track releases going forward)
- Jun 2018: Memory model @ PLDI

Plans

- Q3’18 — Q4’18: Implement missing features, upstream prerequisites to trunk
- Q1’19 — Q2’19: Submit feature-based PRs to upstream

ALSO

- Avoid become C++
- MC programs verification
- Multicore MirageOS
- Libs & ports
- Lwt (!?)

Sources

- ocaml.org
- ocamllabs.io
- gh -> ocaml-multicore
- kcsrk.info | gh -> @kayceesrk | twi -> @kc_srk
- gh -> kayceesrk/effects-examples
- gh -> ocamllabs/ocaml-effects-tutorial
- reddit -> r/ocaml
- discord -> ocaml
- irc -> freenode #ocaml

THNX

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