<h1>MirageOS 4</h1>

Explanation & Release

<h3>The MirageOS project</h3>

The MirageOS project is mainly 3 things:

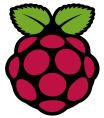
- An ecosystem
- A tool
- Multiple ABIs

<h3>Your MirageOS project</h3>

```
mirage/ mirage-tcpip  ocaml-git     mrmime       bechamel
      / colombe       duff          ocaml-base64 ocaml-x509
      / digestif      encore        ocaml-hex    happy-eyeballs
      / decompress    docteur       ke           ocaml-pgp
      / mirage-crypto paf-le-chien  ocaml-rpc    prometheus
      / ocaml-cohttp  irmin         conan        ocaml-cstruct
      / ocaml-matrix  docteur       eqaf         bloomf
      / ocaml-tls     optint        ca-certs-nss ...
```

```
module Make (_ : _) ... = struct
  let start _ ... : unit Lwt.t =
    my_super_application ()
end
```

Kernel Virtualization Machine Xen VIRTual Input Output SeCure COMPuting mode Raspberry PI 4 Muen UNIX



<h3>3 degrees of freedom</h3>

- Let the user to make its own application
- Choose which **implementations** will be use to concretize required *devices* by your application
- Choose which *target* you want to **deploy** you application

<h3>A *device*</h3>

A *device* is a **specification** (an OCaml module signature) which can **interacts** with a physical components of a computer. It can be:

```
module type KV = sig
  type t
  type key and value

  val read : t -> key -> value Lwt.t
  val write : t -> key -> value -> unit Lwt.t
end
```

A *KV*-store like a file-system

```
module type FLOW = sig
  type t

  val read : t -> bytes -> [ `Eof | `Data of int ] Lwt.t
  val write : t -> string -> unit Lwt.t
  val close : t -> unit Lwt.t
end
```

An *ongoing* connection with a peer

```
module type CLOCK = sig
  type t

  val now : t -> int64 Lwt.t
end
```

A clock

```
module type CONSOLE = sig
  type t

  val log : ('a, Format.formatter, unit, unit Lwt.t) format4 -> 'a
end
```

A console to *print-out* messages

<h3>A higher *implementation* from lower *devices*</h3>

An implementation which **provides** a *device* (a **specification**) can require multiple *devices*:

```
module Make_LITTLEFS : KV =
  functor (Block : BLOCK) ->
  functor (Posix_clock : PCLOCK) ->
  struct ... end
```

```
module Make_TCPIP : FLOW =
  functor (Time : TIME) ->
  functor (Random : RANDOM) ->
  functor (Netif : NETIF) ->
  functor (Ethernet : ETHERNET) ->
  functor (Arp : ARP) ->
  functor (Ip : IP) ->
  functor (Monotonic_clock : MCLOCK) ->
  struct ... end
```

```
module Make_TLS : FLOW =
  functor (Flow : FLOW) ->
  struct ... end
```

<h3>A higher *implementation* from lower *devices*</h3>

An implementation which **provides** a *device* (a **specification**) can require multiple *devices*:

```
module Make_LITTLEFS : KV =
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  struct ... end
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module Make_TCPIP : FLOW =
  functor (Time : TIME) ->
  functor (Random : RANDOM) ->
  functor (Netif : NETIF) ->
  functor (Ethernet : ETHERNET) ->
  functor (Arp : ARP) ->
  functor (Ip : IP) ->
  functor (Monotonic_clock : MCLOCK) ->
  struct ... end
```

```
module Make_TLS : FLOW =
  functor (Flow : FLOW) ->
  struct ... end
```

unikernel.ml

```
module Make
  (Console : CONSOLE)
  (Flow : FLOW)
  (Store : KV) = struct
  let start console flow store =
    my_super_application console flow store
end
```

<h3>Resolve & Compose everything</h3>

OPAM tries to resolve a solution about *required* devices.
Functoria composes implementations/devices from the given solution.

```
module Make
  (Console : CONSOLE)
  (Flow : FLOW)
  (Store : KV) = struct
  let start console flow store =
    my_super_application console flow store
end
```

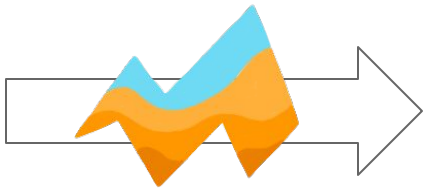
unikernel.ml

```
let unikernel =
  foreign "Unikernel.Make"
    (console @-> flow @-> kv @-> job)

let my_flow = with_tls tcpip_flow

let () =
  register "my_super_application"
    [ unikernel $ default_console $ my_flow $
littlefs ]
```

config.ml



As a resolver

```
name: "my_super_application"
depends: [
  "mirage-console-target"
  "mirage-crypto-rng-mirage"
  "mirage-mclock-target"
  "mirage-pclock-target"
  "mirage-block-target"
  "mirage-time-lwt"
  "mirage-netif-target"
  "mirage-tcpip"
  "ocaml-tls"
  "littlefs"
]
```

my_super_application.opam

```
module Console = Mirage_console_target
module Random = Mirage_crypto_rng
module Monotonic_clock = Mirage_monotonic_clock_target
module Posix_clock = Mirage_posix_clock_target
module Block = Mirage_block_target
module Time = Mirage_time_lwt
module Netif = Mirage_netif

module My_ethernet = Make_ETHERNET(...)
module My_ARP = Make_APR(...)
module My_IP = Make_IP(...)
module My_TCPIP = Make_TCPIP
  (Time)
  (Random)
  (Netif)
  (My_ethernet)
  (My_ARP)(My_IP)
  (Monotonic_clock)
module My_flow = Make_TLS(TCPIP_Flow)
module My_KV = Make_LITTLEFS(Block)(Posix_clock)

include Make (Console) (My_flow) (My_KV)

let () =
  let console = Console.connect () in
  let random = Random.connect () in
  let mclock = Monotonic_clock.connect () in
  let pclock = Posix_clock.connect () in
  let block = Block.connect () in
  ...
  let littlefs = My_KV.connect block pclock in
  ... start console my_flow littlefs
```

main.ml

<h3>Link everything</h3>

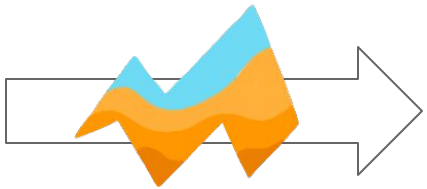
Fetch and **compile** dependencies.
Compile and **link** application and dependencies to a final **object** file.

```
mirage_console_target.cmxa
mirage_crypto_rng_mirage.cmxa
mirage_mclock_target.cmxa
mirage_pclock_tartget.cmxa
mirage_block_target.cmxa
mirage_time_lwt.cmxa
mirage_netif_target.cmxa
mirage_tcpip.cmxa
ocaml_tls.cmxa
littlefs.cmxa
    +     transitive dependencies
```

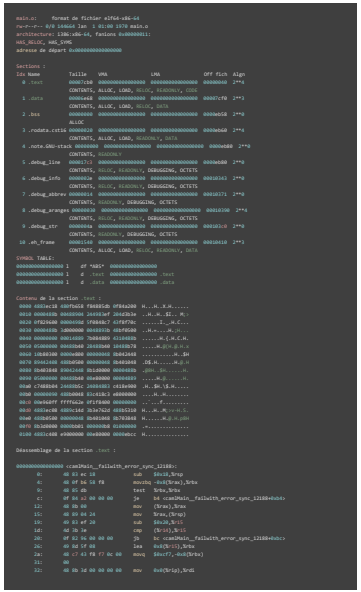
Compiled libraries

```
unikernel.cmx
main.cmx
```

Compiled application



As a compiler

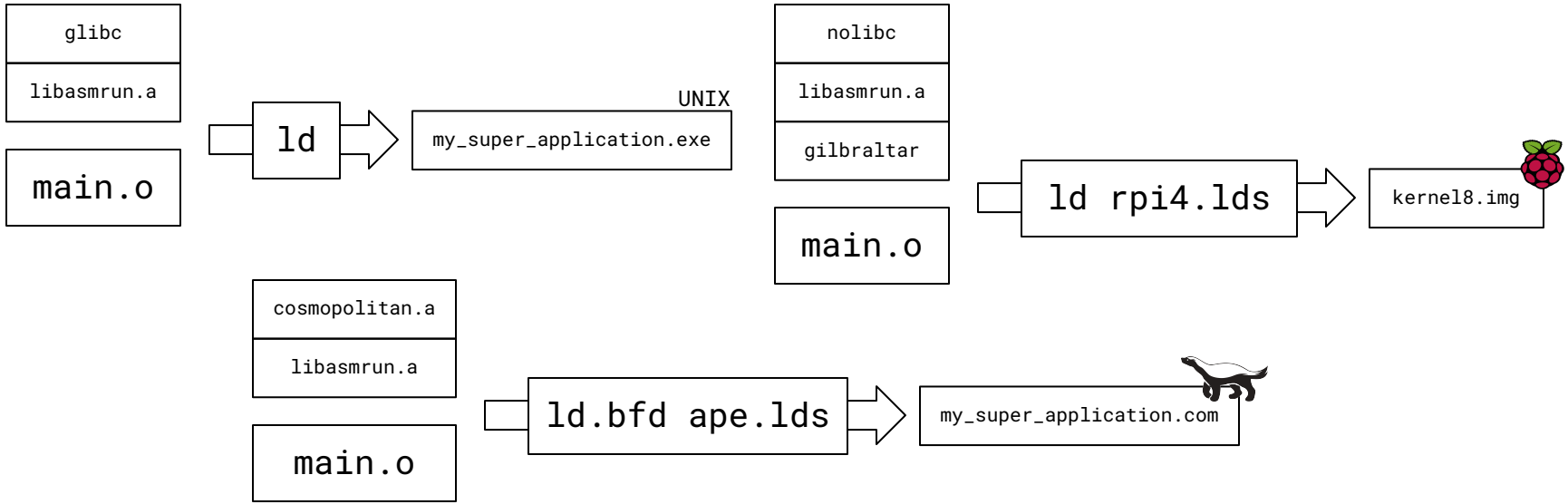


One and unique statically linked **object** file **main.o**

<h3>A *target*</h3>

A *target* is an ABI defined by:

- An **object** which provides few *functions*/***syscalls*** to interact with the system
  and the **caml runtime** (a *micro-kernel* or a *startup* **object** file)
- A **link script** to well-craft the final artifact (to an OS, an executable, etc.)
- A *toolchain* as a **coherent** context to build the final artifact

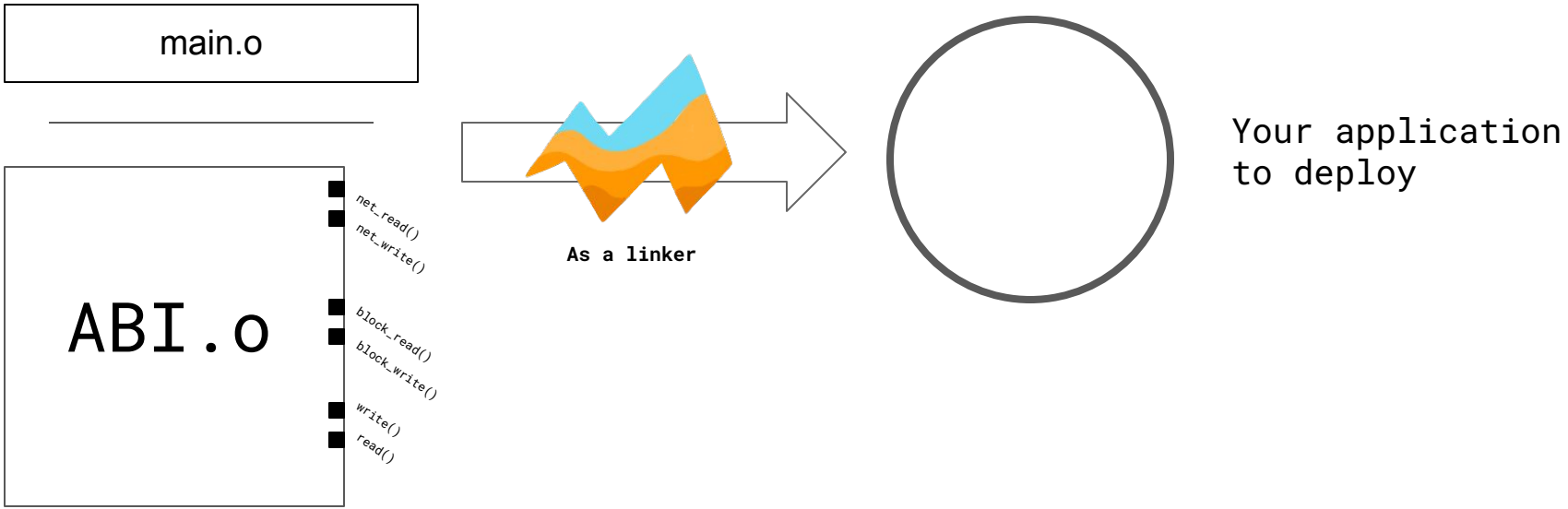


<h3>Craft everything(?)</h3>

Follow instructions to craft your application with the chosen ABI.

(the chosen ABI **implements** final and concrete function to interact with your computer)

Link everything into your final artifact!



<h3>The mirage tool</h3>

```
mirage/ mirage-tcpip  ocaml-git     mrmime       bechamel
      / colombe       duff          ocaml-base64 ocaml-x509
      / digestif      encore        ocaml-hex    happy-eyeballs
      / decompress    docteur       ke           ocaml-pgp
      / mirage-crypto paf-le-chien  ocaml-rpc    prometheus
      / ocaml-cohttp  irmin         conan        ocaml-cstruct
      / ocaml-matrix  docteur       eqaf         bloomf
      / ocaml-tls     optint        ca-certs-nss ...
```

```
module Make (_ : _) ... = struct
  let start _ ... : unit Lwt.t =
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end
```
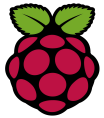

As a resolver

As a compiler

As a linker

Kernel Virtualization Machine Xen VIRTual Input Output SeCure COMPuting mode Raspberry PI 4 Muen UNIX



<h3>A *coherent* tool / A *coherent* context</h3>

MirageOS 4 proposes a change in **the back office** to provide a coherent context for the **user**, the **libraries** and the **ABIs**.

MirageOS 3	MirageOS 4
`*.cmxa` provided by **OPAM** ≠ libasmrun.a of the ABI	**Fetch** & **Build** libraries from **sources**
`%.c: %.o` provided by **OPAM** ≠ libasmrun.a of the ABI	**Fetch** & **Build** C stubs with the ABI's libasmrun.a
`*.o` compiled to the host's ASM ≠ target's ASM	Use an OCaml cross-compiler
Missing well-compiled `*.o` for new targets	Target detached from third-party libraries
No homogeneous context for **merlin**	Host context for **merlin**, target context for final artifact
ocamlbuild	**The monopoly build-system**

<h3>Applications</h3>

MirageOS 4 came with several new applications which was made along the release (2~3 years).

<h3>Applications</h3>

A DNS resolver which trusts only root servers.

https://github.com/mirage/dns-resolver

<h3>Applications</h3>

Unipi, a static website from a Git repository

https://github.com/roburio/unipi

<h3>Applications</h3>

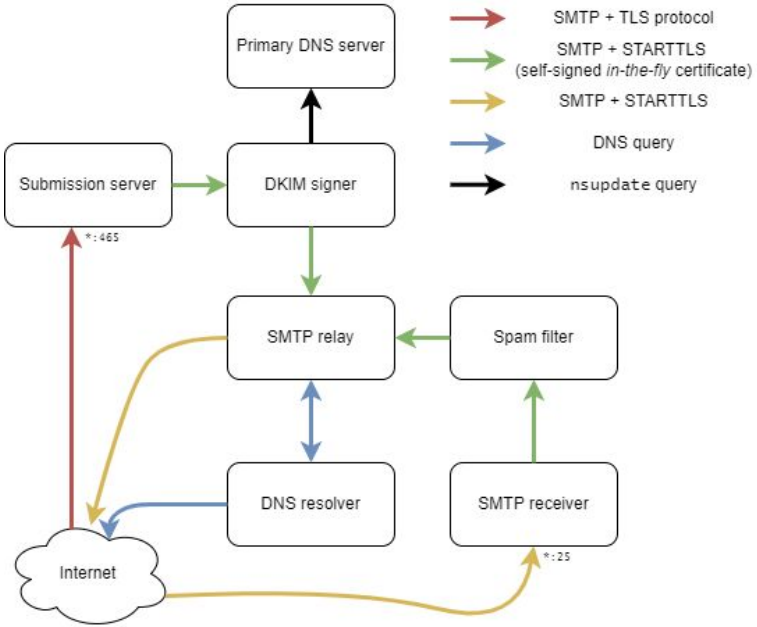
Contruno, a TLS termination proxy (as nginx)

https://github.com/dinosaure/contruno

<h3>Applications</h3>

PTT, a full SMTP service

https://github.com/dinosaure/ptt



<h3>Applications</h3>

And many others:

https://github.com/roburio/dns-primary-git
https://github.com/roburio/dns-letsencrypt-secondary
https://github.com/yomimono/url-shortener
https://github.com/renatoalencar/ocaml-socks-client
https://github.com/roburio/tlstunnel
https://github.com/dinosaure/cri
https://github.com/palainp/mirage-sshfs
https://github.com/mirage/qubes-mirage-firewall

<h3>Thanks</h3>

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- @Dinoosaure
- @dinosaure@mastodon.social
- romain.calascibetta@gmail.com
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