

Introduction

Manipulating data

From loops to enumeration

Other data structures

I/O

From Channels to I/O

Composability

Extensibility

Text

From string to...

Features

Conclusion

# OCaml, Batteries Included

OCaml Meeting 2009

David Teller<sup>1</sup>, Edgar Friendly, Stefano Zacchiroli<sup>2</sup>, Gabriel  
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<sup>2</sup>PPS, Université Paris 7

February 4th, 2009

# Before we start



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# What makes a good language?

Safety  
Expressivity  
Composability  
Syntax  
Simplicity  
Fun factor

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# Popular languages

What about:

Java

C#

VB

Python

JS

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# Popular languages

What about:

	Safe
<b>Java</b>	ok
<b>C#</b>	ok
<b>VB</b>	bad
<b>Python</b>	bad
<b>JS</b>	bad

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# Popular languages

What about:

	Safe	Expressive
<b>Java</b>	ok	ugly
<b>C#</b>	ok	bad → ok
<b>VB</b>	bad	bad
<b>Python</b>	bad	ok
<b>JS</b>	bad	bad → ok

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<b>C#</b>	ok	bad $\rightarrow$ ok	ok
<b>VB</b>	bad	bad	bad
<b>Python</b>	bad	ok	good
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Good  $\nleftrightarrow$  Popular

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Good  $\nLeftrightarrow$  Popular  
OCaml  $\notin$  Popular (yet)

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# What makes a successful language?

Maybe something like:

**Well-suited library** (sometimes the only available library)

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# What makes a successful language?

Maybe something like:

**Well-suited library** (sometimes the only available library)

**Consistent/composable library** (only one string type, only one iteration type, only one exception hierarchy...)

**Extensibility** (new kinds of streams may be created, virtual file system...)

**Tutorials** (which should be trivial to find)

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**Extensibility** (new kinds of streams may be created, virtual file system...)

**Tutorials** (which should be trivial to find)  
either

**Fun factor**  
or

**Public relations** (either a company or open-source buzz)

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# And in OCaml?

**Well-suited library** Low-level library in a high-level language.  
Minimal library sufficient for testing, not necessarily for development.

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**Well-suited library** Low-level library in a high-level language.  
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**Public relations** Insufficient. Despite competition with Haskell.

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# What can we improve?

Well-suited library Build a high-level library.

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**Well-suited library** Build a high-level library.

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**Tutorials** Improve documentation.

**Fun factor** Can always be improved. Cabal?

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**Fun factor** Can always be improved. Cabal?

**Public relations** OCaml Developer Days, OCamlCore.org, books, teaching, etc.

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# Introducing



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# Our objectives

A distribution of OCaml with

- ▶ Newbie-oriented documentation.
- ▶ More comfortable syntax.
- ▶ Consistent and high-level API.
- ▶ Extensible data structures.

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# Our objectives

A distribution of OCaml with

- ▶ Newbie-oriented documentation.
- ▶ More comfortable syntax.
- ▶ Consistent and high-level API.
- ▶ Extensible data structures.
- ▶ More fun!

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# How?

**API** Existing libraries + uniformization “glue layer”.

**Language** Syntax extensions, auto-loaded.

**Toolchain** Existing tools + transparent shell scripts.

**Documentation** Largely rewritten + new doclet.

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Improve the user experience, don't reinvent the wheel!

Don't turn OCaml into Java!

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Built on top of the Base library and ExtLib.

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# Step 1

- Objective** Simplify and uniformize data structure access.
- Objective** Decrease need for multi-paradigm for simple tasks.

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# What is this for?

OCaml has

built-in specialized loops `for`, `while`

data structure-based loops `List.iter`, `List.fold_left`,  
`List.fold_right`, `List.map`...

built-in general loops `let rec`

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**built-in general loops** `let rec` (general mechanism for implementing loops)

- ▶ Specialized loops are optimizations.
- ▶ `let rec` is (among other things) an extension mechanism.

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# Enter enumerations

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Overview Lightweight iterators, aka “like `Stream.t`, but open”.



# Enter enumerations

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**Overview** Lightweight iterators, aka “like `Stream.t`, but open”.

**Operations** `foreach/iter`, `map`, `fold`, `scanl`, `filter`,  
`flatten`

# Enter enumerations

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**Overview** Lightweight iterators, aka “like `Stream.t`, but open”.

**Operations** `foreach/iter`, `map`, `fold`, `scanl`, `filter`, `flatten`

**Conversion** `List.enum/List.backwards/`  
`Array.enum/Array.backwards/`  
`Hashtbl.enum/Hashtbl.keys/Hashtbl.values/`  
`String.enum/String.backwards/ ...`

**Construction** `( - )`, `( -- )`, `( ~~~ )`, `unfold`, etc.

**Source** `ExtLib`, `SDFlow`, new stuff

# Examples

**Exercise** Count from 1 to 10.

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# Examples

**Exercise** Count from 1 to 10.

```
1 -- 10
```

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# Examples

**Exercise** Count from 1 to 10.

```
1 -- 10
```

**Exercise** Print all elements between 1 to 10.

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# Examples

**Exercise** Count from 1 to 10.

```
1 -- 10
```

**Exercise** Print all elements between 1 to 10.

```
let print_intln x =  
    print_int x;  
    print_newline ();;  
foreach ( 1 -- 10 ) print_intln
```

# Examples (2)

**Exercise** Print the square numbers of all odd numbers between 1 and 100, by decreasing order.

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# Examples (2)

**Exercise** Print the square numbers of all odd numbers between 1 and 100, by decreasing order.

```
let square x = x * x
and odd     x = x mod 2 = 1
in
foreach ( map square ( ( 100 --- 1 ) // odd) )
  print_intln
```



## Examples (2)

**Exercise** Print the square numbers of all odd numbers between 1 and 100, by decreasing order.

```
let square x = x * x
and odd      x = x mod 2 = 1
in
foreach ( map square ( ( 100 --- 1 ) // odd) )
  print_intln
```

Did I mention syntax extensions?

```
foreach [? x*x | x <- ( 100 --- 1 ); x mod 2 = 1]
  print_intln
```

# Examples (3)

**Exercise** Keep only the vowels of “OCaml is too cool for school”.

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# Examples (3)

**Exercise** Keep only the vowels of “OCaml is too cool for school”.

```
let too_cool = "OCaml is too cool for school" in
String.of_enum(
  (String.enum too_cool) //
    (function 'a'|'e'|'i'|'o'|'u'
      | 'A'|'E'|'I'|'O'|'U' -> true
      | _                  -> false))
```

# Examples (3)

**Exercise** Keep only the vowels of “OCaml is too cool for school”.

```
let too_cool = "OCaml is too cool for school" in
String.of_enum(
  (String.enum too_cool) //
    (function 'a'|'e'|'i'|'o'|'u'
      | 'A'|'E'|'I'|'O'|'U' -> true
      | _                    -> false))
```

Syntax extensions, again:

```
[? String : x | x <- String : too_cool ; vowel x]
where vowel = function 'a'|'e'|'i'|'o'|'u'
  | 'A'|'E'|'I'|'O'|'U' -> true
  | _                    -> false
```

# Other data structures

- ▶ Doubly-linked lists, defunctorized polymorphic maps, multi-maps, dynamic arrays, lazy lists, defunctorized polymorphic sets, ...

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# Other data structures

- ▶ Doubly-linked lists, defunctorized polymorphic maps, multi-maps, dynamic arrays, lazy lists, defunctorized polymorphic sets, ...
- ▶ Upgraded lists, arrays, big arrays, hashtables, queues, stacks, maps, sets.

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# Other data structures

- ▶ Doubly-linked lists, defunctorized polymorphic maps, multi-maps, dynamic arrays, lazy lists, defunctorized polymorphic sets, ...
- ▶ Upgraded lists, arrays, big arrays, hashtables, queues, stacks, maps, sets.
- ▶ Everything supports Sexplib, printing, enumerations, etc.

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# Other data structures

- ▶ Doubly-linked lists, defunctorized polymorphic maps, multi-maps, dynamic arrays, lazy lists, defunctorized polymorphic sets, ...
- ▶ Upgraded lists, arrays, big arrays, hashtables, queues, stacks, maps, sets.
- ▶ Everything supports Sexplib, printing, enumerations, etc.
- ▶ Most things support comprehension.

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# Channels are closed

```
Jan 30 00:50:25 <sanguinev>      Is there a way to make an output_channel that just
                                accepts output and doesn't do anything?
Jan 30 00:51:23 <brendan>        open_out "/dev/null" ?
Jan 30 00:54:00 <sanguinev>      brendan: I am looking for something that won't require
                                a file/any specified location.
Jan 30 00:54:47 <Yoric[DT]>      Shameless plug: with Batteries, it's possible.
Jan 30 00:55:14 <Yoric[DT]>      (other than that, you could trick it with a pipe, but
                                that's much more complicated than /dev/null)
Jan 30 00:55:50 <sanguinev>      Yoric[DT]: I am hoping for something nice and system
                                agnostic so I can run the same code on linux/unix/
                                mac OSX/cygwin...
```

...

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# Channels are closed

```
Jan 30 00:50:25 <sanguinev>      Is there a way to make an output_channel that just
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                                mac OSX/cygwin...
```

... Also, can't filter/map/... on channels.

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# Channels are closed

```
Jan 30 00:50:25 <sanguinev>      Is there a way to make an output_channel that just
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Jan 30 00:55:50 <sanguinev>      Yoric[DT]: I am hoping for something nice and system
                                agnostic so I can run the same code on linux/unix/
                                mac OSX/cygwin...
```

... Also, can't filter/map/... on channels. Shameless plug #2:  
channel #ocaml is open, though.

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# What's going on?

OCaml's `in_channel/out_channel` are

- ▶ operating system-level
- ▶ tied to the Unix model
- ▶ closed.

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# Enter input/output

**Overview** Drop-in replacement for `in_channel/out_channel` operations.

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# Enter input/output

**Overview** Drop-in replacement for `in_channel/out_channel` operations.

**Operations** All the usual operations, plus i/o filters, position, callbacks, Unicode, auto-flushing...

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# Enter input/output

**Overview** Drop-in replacement for `in_channel/out_channel` operations.

**Operations** All the usual operations, plus i/o filters, position, callbacks, Unicode, auto-flushing...

**Conversion** To/from enumerations, strings, file names, sockets, processes...

**Construction** `File.open_in/open_out`,  
`wrap_in/wrap_out`...

**Source** ExtLib, OCamlNet, Camomile, more stuff

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# Let's do it with Batteries

**Exercise** Let's implement cat with Batteries.

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# Let's do it with Batteries

**Exercise** Let's implement cat with Batteries.

```
open IO, File
foreach (args ())
  (fun s -> copy (open_in s) stdout)
```

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# Let's do it with Batteries

**Exercise** Let's implement cat with Batteries.

```
open IO, File
foreach (args ())
  (fun s -> copy (open_in s) stdout)
```

or

```
foreach (args ()) **>
  fun s -> copy (open_in s) stdout
```

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# Let's do it with Batteries (2)

**Exercise** Now, let's implement a version of cat which prints line numbers along with line contents.

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# Let's do it with Batteries (2)

**Exercise** Now, let's implement a version of cat which prints line numbers along with line contents.

```
open IO
foreach (args ()) (fun s ->
  Enum.iteri
    (Printf.printf "%d %s\n")
    (File.lines_of s)
  )
```

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# Let's do it with Batteries (2)

**Exercise** Now, let's implement a version of cat which prints line numbers along with line contents.

```
open IO
foreach (args ()) (fun s ->
  Enum.iteri
    (Printf.printf "%d %s\n")
    (File.lines_of s)
)
```

In this last version, a file was automatically opened, read (lazily), split into lines and closed.

# Going further

**Exercise** Add gzip-decompression.

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# Going further

**Exercise** Add gzip-decompression.

```
open IO
foreach (args ()) (fun s ->
  Enum.iteri
    (Printf.printf "%d %s\n")
    (lines_of (GZip.uncompress (File.open_in s)))
)
```

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# Going further

**Exercise** Add gzip-decompression.

```
open IO
foreach (args ()) (fun s ->
  Enum.iteri
    (Printf.printf "%d %s\n")
    (lines_of (GZip.uncompress (File.open_in s)))
)
```

**Exercise** Count number of bytes read.

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# Going further

**Exercise** Add gzip-decompression.

```
open IO
foreach (args ()) (fun s ->
  Enum.iteri
    (Printf.printf "%d %s\n")
    (lines_of (GZip.uncompress (File.open_in s)))
)
```

**Exercise** Count number of bytes read.

```
foreach (args ()) (fun s ->
  let (inp, pos) = pos_in (File.open_in s) in
  Enum.iteri
    (Printf.printf "%d %s\n")
    (lines_of (GZip.uncompress inp));
  Printf.printf "\tRead %d bytes\n" (pos ())
)
```

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# Going further

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foreach (args ()) (fun s ->
  Enum.iteri
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```

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```
foreach (args ()) (fun s ->
  let (inp, pos) = pos_in (File.open_in s) in
  Enum.iteri
    (Printf.printf "%d %s\n")
    (lines_of (GZip.uncompress inp));
  Printf.printf "\tRead %d bytes\n" (pos ())
)
```

etc.

# I/O is open

Want to read from a string, a socket, an http connexion, etc?

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# I/O is open

Want to read from a string, a socket, an http connexion, etc?  
Writing new inputs/outputs is easy.

```
val create_in:
  read:(unit -> char) ->
  input:(string -> int -> int -> int) ->
  close:(unit -> unit) ->
  input
val wrap_in:
  read:(unit -> char) ->
  input:(string -> int -> int -> int) ->
  close:(unit -> unit) ->
  underlying:(input list) ->
  input
```

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# The problem with strings

Strings are mutable, hence:

difficult to trust

sloooow to append.

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# The problem with strings

Strings are mutable, hence:

- difficult to trust

- sloooow to append.

Strings are arrays of `char`, hence:

- confuse *characters* and *bytes*

- have no clear notion of encoding.

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# Introducing ropes

```
r"This is a UTF-8 encoded rope"
```

**Overview** Functional UTF-8 encoded text with  $\mathcal{O}(\ln(n))$  concatenation but slower get.

**Limitations** About 700Mb in 32-bit, about 220Gb in 64-bit.

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# Introducing ropes

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**Operations** All the operations of String except mutability.

**Conversion** `Rope.of_latin1`, `Rope.of_uchar`, ...

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**Limitations** About 700Mb in 32-bit, about 220Gb in 64-bit.

**Operations** All the operations of String except mutability.

**Conversion** `Rope.of_latin1`, `Rope.of_uchar`, ...

**Notes** Allocation optimized (with Camlp4!), immutable implementation.

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# Introducing string with capabilities

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```
ro "... a read-only Latin-1 string";;  
wo "... a write-only Latin-1 string";;  
rw "... a read-write Latin-1 string";;
```

**Overview** Your usual strings, but with phantom types to ensure read-only/write-only/read-write capability.

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# Introducing string with capabilities

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# Introducing string with capabilities

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```
ro "... a read-only Latin-1 string";;  
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```

**Overview** Your usual strings, but with phantom types to ensure read-only/write-only/read-write capability.

**Operations** All the operations of String.

**Notes** Optimized allocation for read-only strings.

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# Exercise

**Exercise** From a string `s`, return the first 5 characters, skip the next 3, then return the next 5 characters, the next 5 characters and the rest of the string.

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# Exercise

**Exercise** From a string `s`, return the first 5 characters, skip the next 3, then return the next 5 characters, the next 5 characters and the rest of the string.

```
let hairsplit s =  
  open String in  
  let e = enum s in  
  [? List : of_enum (f e) | f <- List :  
    [take 5; skip 3 |- take 5; take 5; identity]]
```

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# Exercise

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  open String in  
  let e = enum s in  
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```

**Exercise** Same thing, but with Unicode.

# Exercise

**Exercise** From a string `s`, return the first 5 characters, skip the next 3, then return the next 5 characters, the next 5 characters and the rest of the string.

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let hairsplit s =  
  open String in  
  let e = enum s in  
  [? List : of_enum (f e) | f <- List :  
    [take 5; skip 3 |- take 5; take 5; identity]]
```

**Exercise** Same thing, but with Unicode.

```
let hairsplit s =  
  open Rope in  
  let e = enum s in  
  [? List : of_enum (f e) | f <- List :  
    [take 5; skip 3 |- take 5; take 5; identity]]
```

# Text features, too

All these data structures support

- ▶ iteration, map, folds, filters, replacement, enumeration, construction from enumeration, searching from left to right, from right to left, from a given index, chopping, trimming, stripping, upper/lowercasing, splitting, slicing, splicing, etc.
- ▶ printing
- ▶ transcoding
- ▶ pattern-matching.

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# Enough for one day

Let's not detail

- ▶ uniform number modules for functorization
- ▶ safe integers
- ▶ enumerable signature
- ▶ on-line help
- ▶ documentation by topics
- ▶ mostly flat module-space
- ▶ overlay modules for labels or exceptionless error management
- ▶ the Future module
- ▶ printing
- ▶ marshaling
- ▶ substrings
- ▶ path management
- ▶ package management
- ▶ calling the compilers from a module
- ▶ ...

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# Status

**Latest version** Alpha 3 for OCaml 3.10/3.11 being bugsquashed.

**Site** <http://batteries.forge.ocamlcore.org>.

**License** Mostly LGPL + LE, bits in BSD.

**Availability** Tarball, GODI package.

**Tools** ocaml, ocamlc, ocamlpt, ocamlcp, ocamlbuild.

**Size** 27,650 loc signatures, 24,407 loc implementations.

**Next version** Beta 1, expected ca. March.

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**Applications** Extrapol static analyzer for C.

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# Batteries for new apps

**Larger standard library** No more reimplementing lazy lists or standard operators or trivial list functions.

**Higher-level library** More composability, more extensibility, etc.

**Syntactic sugar** More readable algorithms.

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**Documentation** More examples, on-line help.

**Uniformity** Modules follow more rigorous patterns and should be easier to learn.

**Purity** Going imperative is less often necessary.

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# Batteries for new libraries

Conventions Standard signatures, obsolete primitives, etc.

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# Batteries for new libraries

Conventions Standard signatures, obsolete primitives, etc.

Better composition

Fun!

Essentially, please consider compatibility with Batteries for your next libraries.

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# Problems to solve

- ▶ Huge binary size.
- ▶ Toplevel pretty-printers.
- ▶ Confusing error messages.
- ▶ Operator precedence for  $\triangleleft$ ,  $\triangleright$ .
- ▶ One-tarball distribution? Symbiosis?

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# In the future

- ▶ More OCamlNet ( $\beta$ ).
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- ▶ AST/bytecode generation?
- ▶ Functional unparsing with Camlp4 support?
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- ▶ **And** our bug tracker, of course.

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# Thank you

Questions?

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# If you're...

- ▶ A PhD, a PhD student or a future PhD student.
- ▶ Into OCaml, similar languages or Coq.
- ▶ Into compilers, concurrency, distributed systems, semantics, proof of programs.
- ▶ Into language tools, language front-ends, language design.
- ▶ Interested by safe programming for the web.



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Contact me/us: MLState may have a job/PhD/internship for you.