Multi-ML: Programming Multi-BSP Algorithms in ML

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Bulk Synchronous Parallelism

The BSP computer

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- **p** pairs CPU/memory

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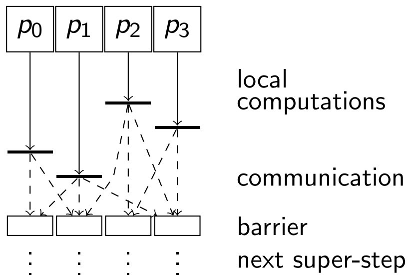
Properties:

- Super-steps execution



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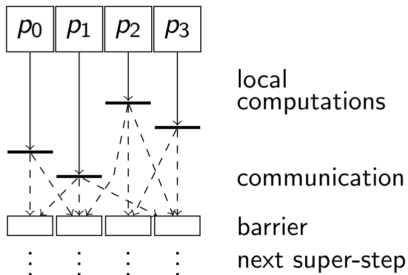

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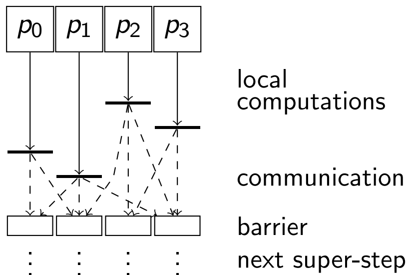

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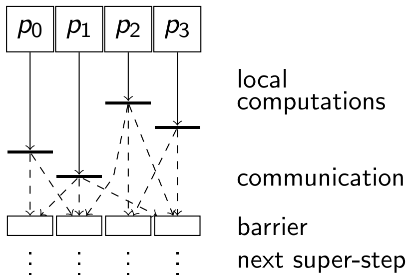

What is BSML?

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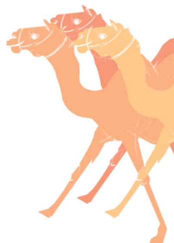
- Explicit BSP programming with a functional approach



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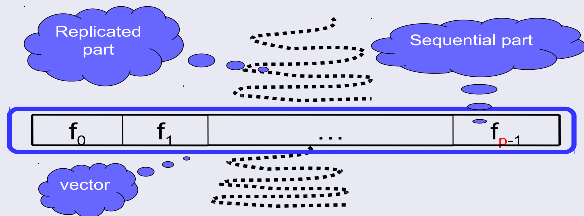
Main idea

Parallel data structure ⇒ vectors:



Asynchronous primitives

BSML primitives

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Synchronous primitives

- **proj** : $\langle x_0, \ldots, x_{\mathbf{p}-1} \rangle \mapsto$ (**fun** $i \to x_i$)

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Synchronous primitives

- **proj** : $\langle x_0, \ldots, x_{\mathbf{p}-1} \rangle \mapsto (\textbf{fun } i \to x_i)$
- **put** : $\langle f_0, \ldots, f_{\mathbf{p}-1} \rangle \mapsto \langle (\textbf{fun } i \to f_i\ 0), \ldots, (\textbf{fun } i \to f_i\ (\mathbf{p}-1)) \rangle$

Code example

For a BSP machine with 3 processors:

```
# let vec = ≪ "HLPP␣" ≫ ;;
val vec : string par = <"HLPP␣", "HLPP␣", "HLPP␣">

# let vec2 = ≪ $vec$^(string_of_int $pid$) ≫ ;;
val vec2 : string par = <"HLPP␣0", "HLPP␣1", "HLPP␣2">

# let totex v = List.map (proj v) procs;;
val totex : 'a Bsml.par → 'a list = <fun>

# totex vec2;;
— : string list = ["HLPP0"; "HLPP1"; "HLPP2"]
```

What is MULTI-BSP?

The MULTI-BSP model

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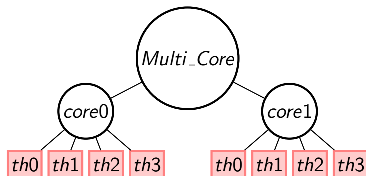

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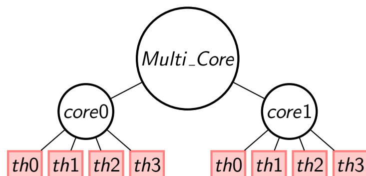
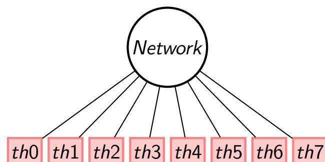
MULTI-BSP



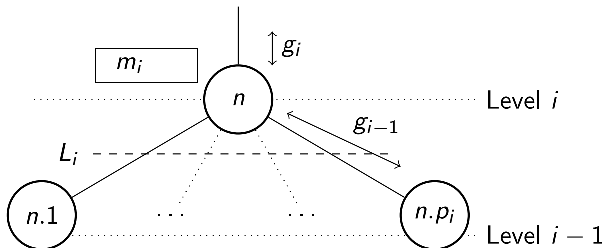
BSP



The MULTI-BSP model

Execution model

A level i superstep is:



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A level i superstep is:

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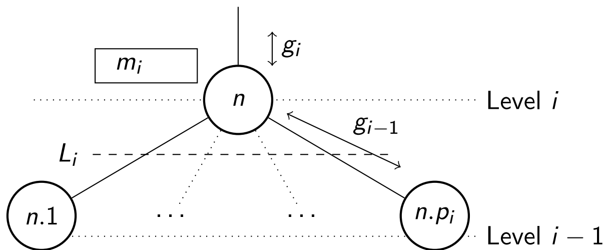

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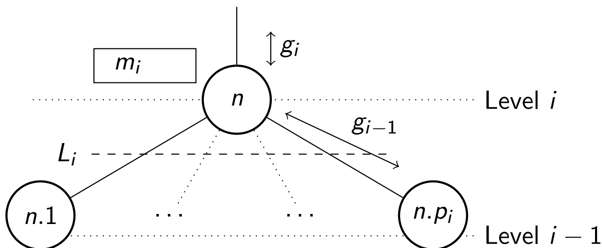
A level i superstep is:

- Level $i-1$ executes code independantly
- Exchanges informations with the m_i memory

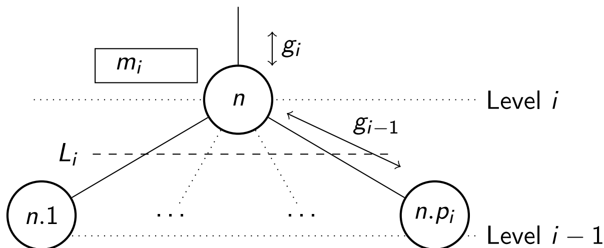


The MULTI-BSP model

Execution model

A level i superstep is:

- Level $i - 1$ executes code independantly
- Exchanges informations with the m_i memory
- Synchronises



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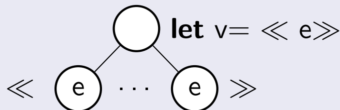

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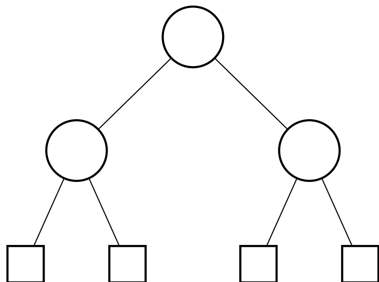

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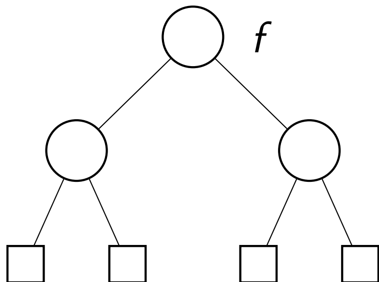

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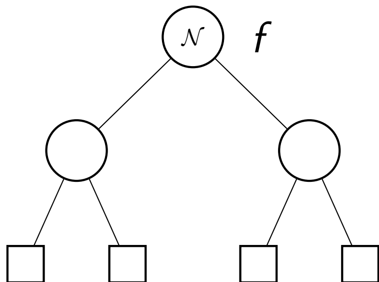

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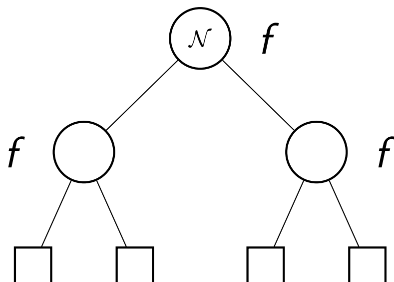

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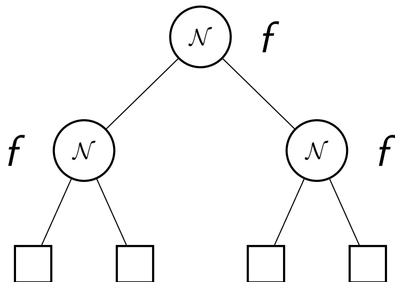

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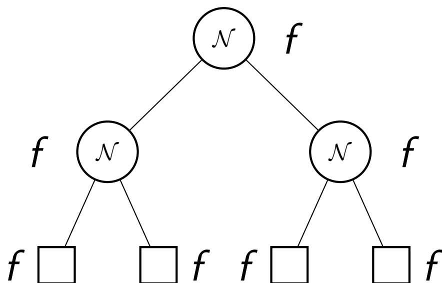

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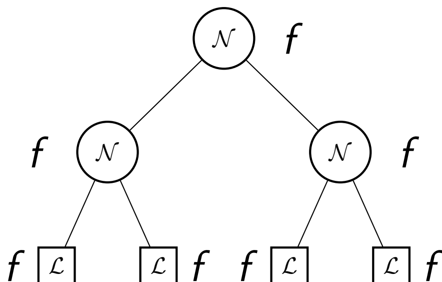

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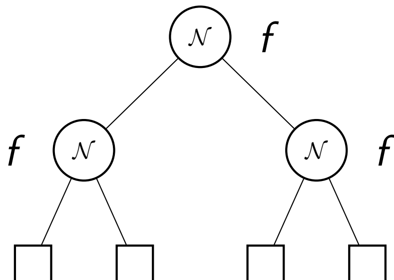

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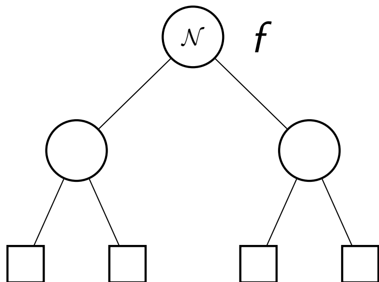

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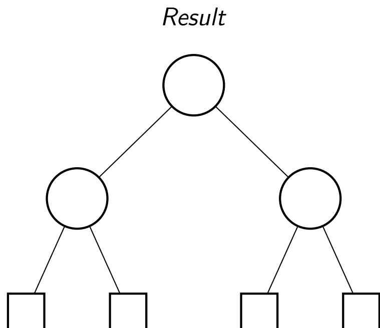

Primitives

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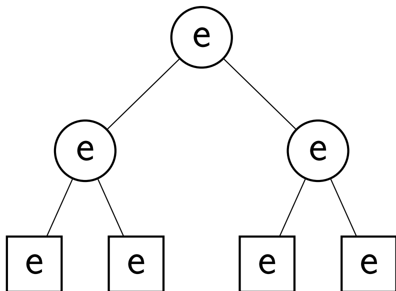

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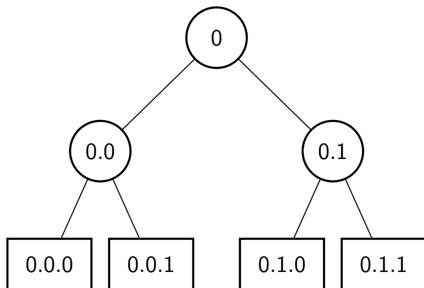

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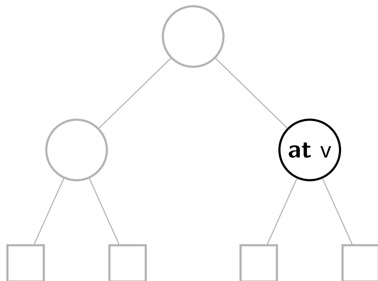

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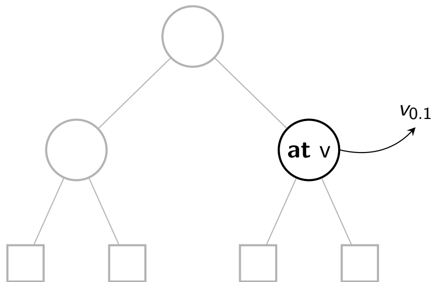

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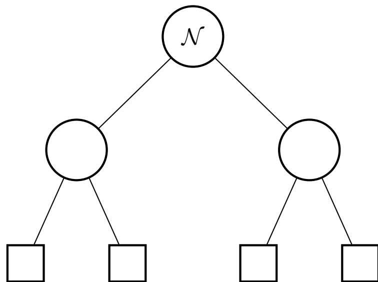

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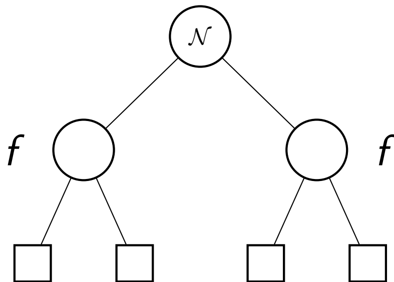

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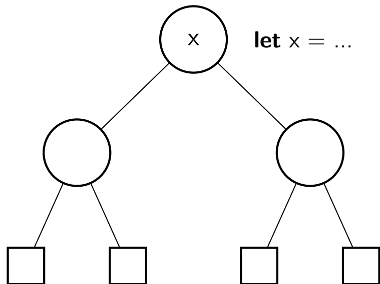

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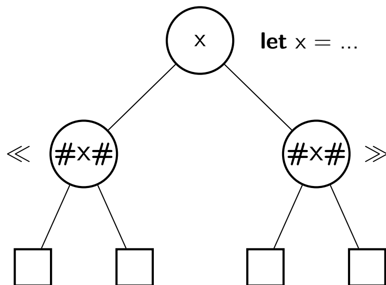

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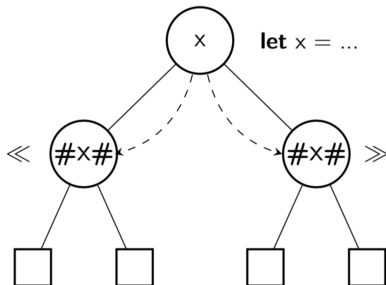

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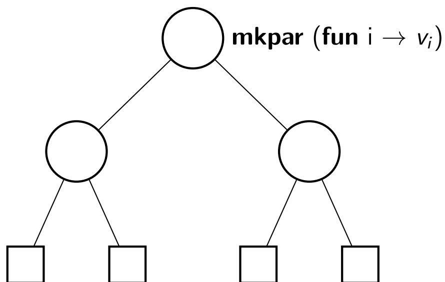

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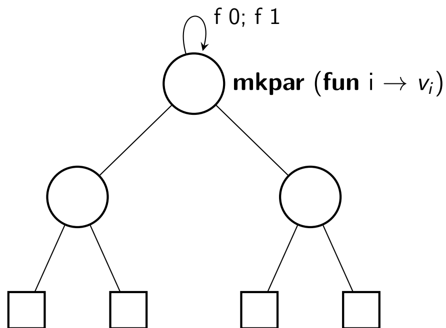

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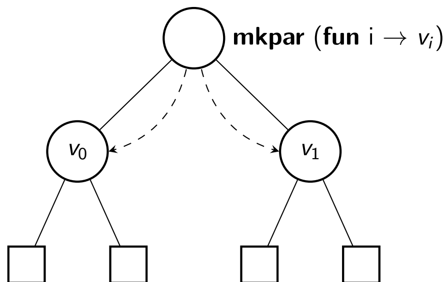

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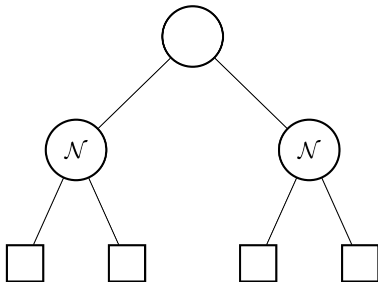

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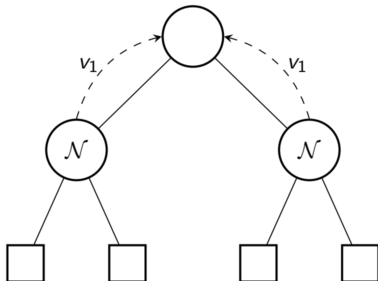

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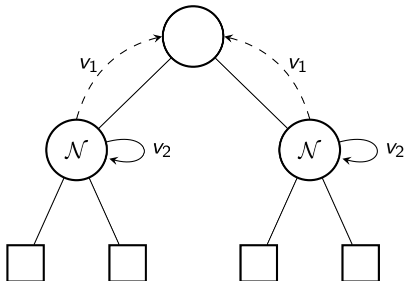

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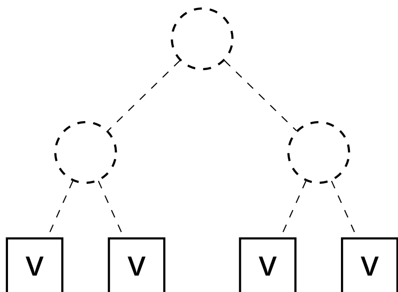

Code example

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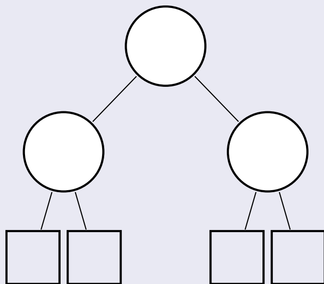

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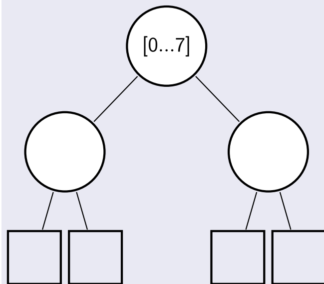


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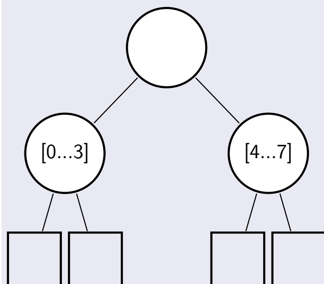


```
let multi tree sum_list l =
  where node =
    let v = mkpar (fun i → split i l) in
    let s = sumSeq (flatten ≪ sum_list $v$≫ ) in
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  where leaf =
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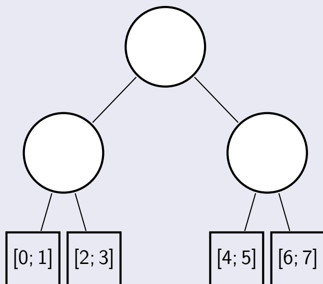


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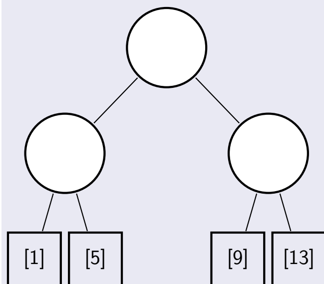


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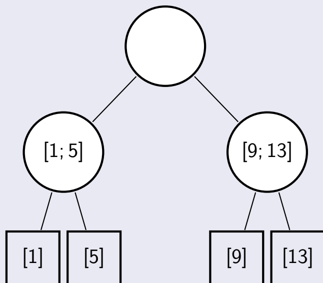


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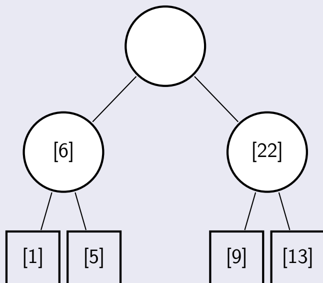


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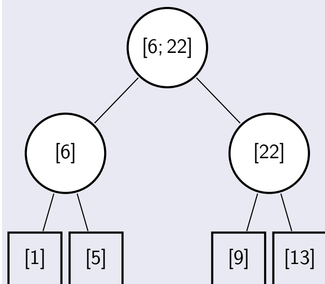


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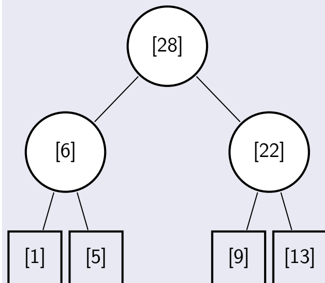


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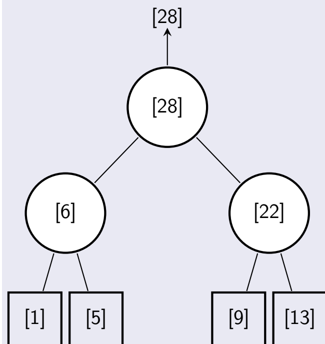


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Formal definition of a core-languge

Useful for:

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- Study of properties

Semantics

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Formal definition of a core-languge

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Currently

- Inductive big-step: confluent
- Co-inductive: mutually exclusive

Implementation

Sequential simulator

- OCAML-like toplevel
- Test and debug
- Tree sturcture
- Hash tables to represent memories

```
#let multi f n =
 | where node =
 | | let _=≪f ($pid$ + #n# + 1) ≫ in
 | | | finally ~up:() ~keep:(gid^"=>"^n)
 | where leaf=finally ~up:() ~keep:(gid^"=>"^n);;

— : val f : int→string tree = <multi-fun>
#(f 0)
o "0→ 0"
|
−−o "0.0→ 1"
| | −→ "0.0.0→ 2"
| | −→ "0.0.1→ 3"
−−o "0.1→ 2"
| | −→ "0.1.0→ 3"
| | −→ "0.1.1→ 4"
```

Distributed implementation

Our approach

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- Modular

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Naive Eratosthenes sieve

- $\sqrt(n)$th first prime numbers
- Based on scan
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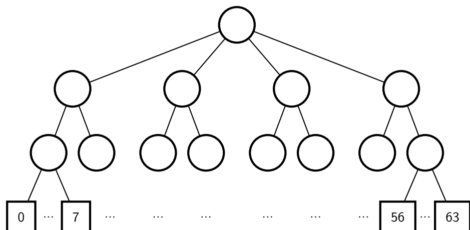

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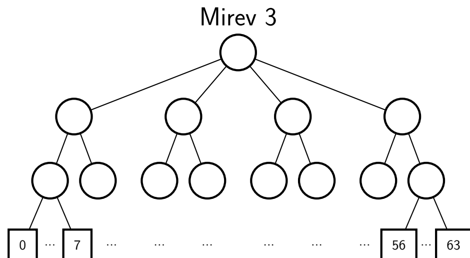

Results

	100_000		500_000		1_000_000	
	MULTI-ML	BSML	MULTI-ML	BSML	MULTI-ML	BSML
8	0.7	1.8	22.4	105.0	125.3	430.7
64	0.3	0.3	1.3	8.7	4.1	56.1
128	0.5	0.45	2.1	5.2	4.7	24.3

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MULTI-ML

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Thank you for your attention !

Any questions ?