Diagrammatic execution models for functional programming

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What happens when you run a functional program by hand?

Running a functional program by hand

```
(* computing the identity function in OCaml *)
(fun _ -> fun x -> fun x) ((fun y -> y) (fun z -> z))


-- computing the identity function in Haskell
(\_ -> \x -> x) ((\y -> y) (\z -> z))
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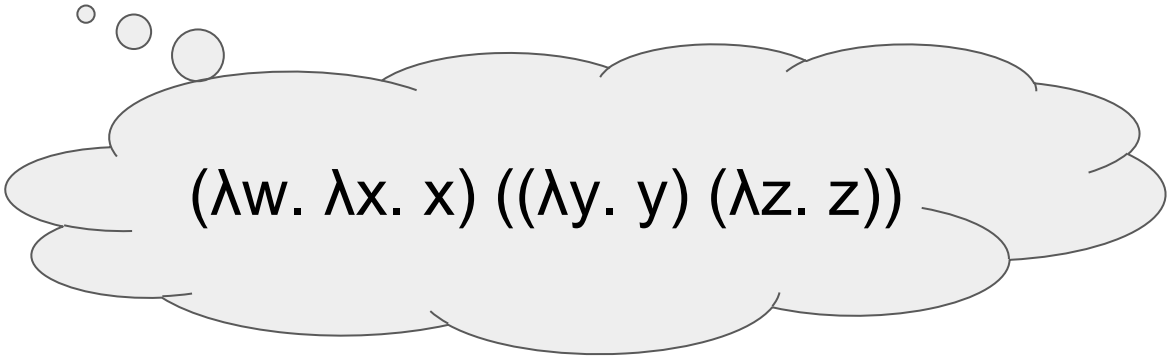

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  (* => (fun _ -> fun x -> x) (fun z -> z)                *)
  (* => fun x -> x                                       *)
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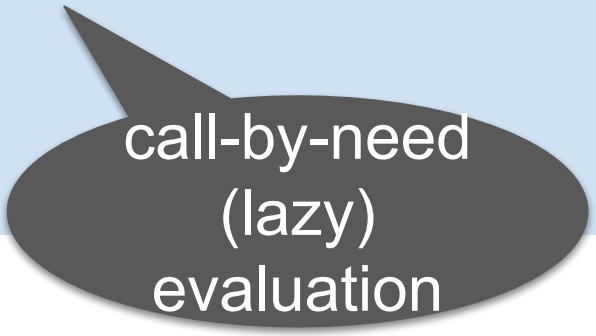

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call-by-value evaluation

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  (* => (fun _ -> fun x -> x) (fun z -> z)               *)
  (* => fun x -> x                                      *)
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call-by-need (lazy) evaluation

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Same result,

but different steps!

Let’s run a functional program with a bit of formality...

Running a functional program, formally

by **change of configuration**

- program
- “focus”

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  (* => (fun _ -> fun x -> x) (fun z -> z)                *)
  (* => fun x -> x                                        *)


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prove program equivalence (validate compiler optimisations)

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- "How *much time/space* does it take to run a program?"
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guarantee "correctness" of implementation

- "Does a compiler work *as intended*?"
- implementation derived as abstract machine

Now we use ***diagrams*** to run a functional program with formality!

Conventional approaches

running a program by

change of configuration

- program
- "focus" *determining evaluation strategy*

Diagrammatic approach

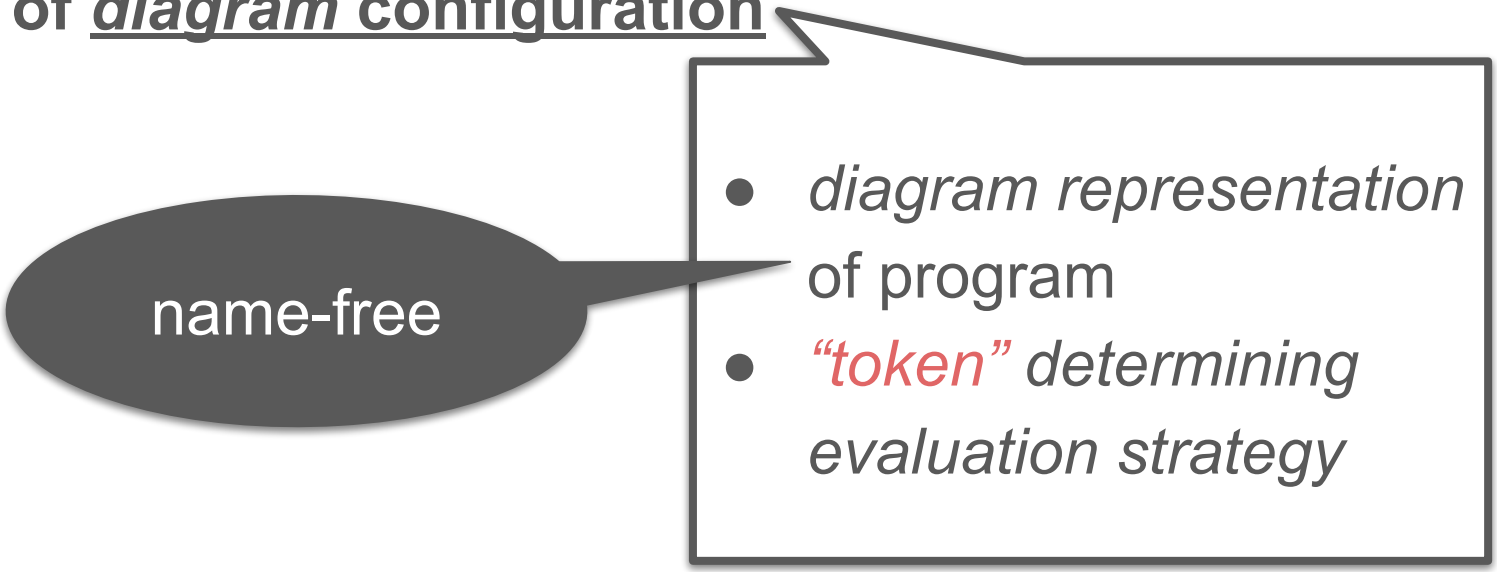
running a program by

change of *diagram* configuration

- *diagram representation* of program
- *"token" determining evaluation strategy*

Running a functional program with *diagrams*

by **change of *diagram* configuration**



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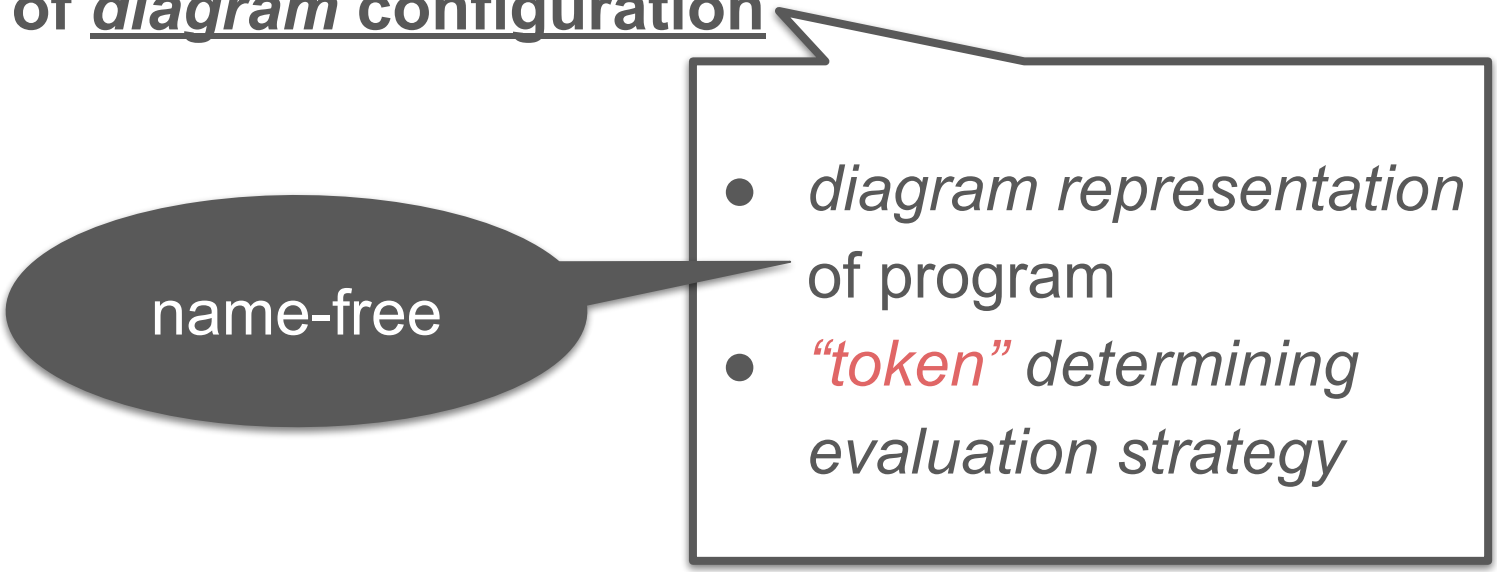

[DEMO]

On-line visualiser for lambda-calculus

https://koko-m.github.io/GoI-Visualiser/

- call-by-name, call-by-need (lazy)
- call-by-value: left-to-right, right-to-left

Goodness of *diagrams*

- name-free
- environment included

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visualise interesting properties of programs

- call-by-value vs. call-by-need (lazy)
- on-demand copying with intermediate sharing
- patterns in divergence
  - (λx. x x) (λx. x x)
  - (λx. x x x) (λx. x x x)

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answer (conventional) questions from new perspectives

- “When are two programs *the same*?”
- “How *much time/space* does it take to run a program?”
- “Does a compiler work *as intended*?”

More goodness of *diagrams*

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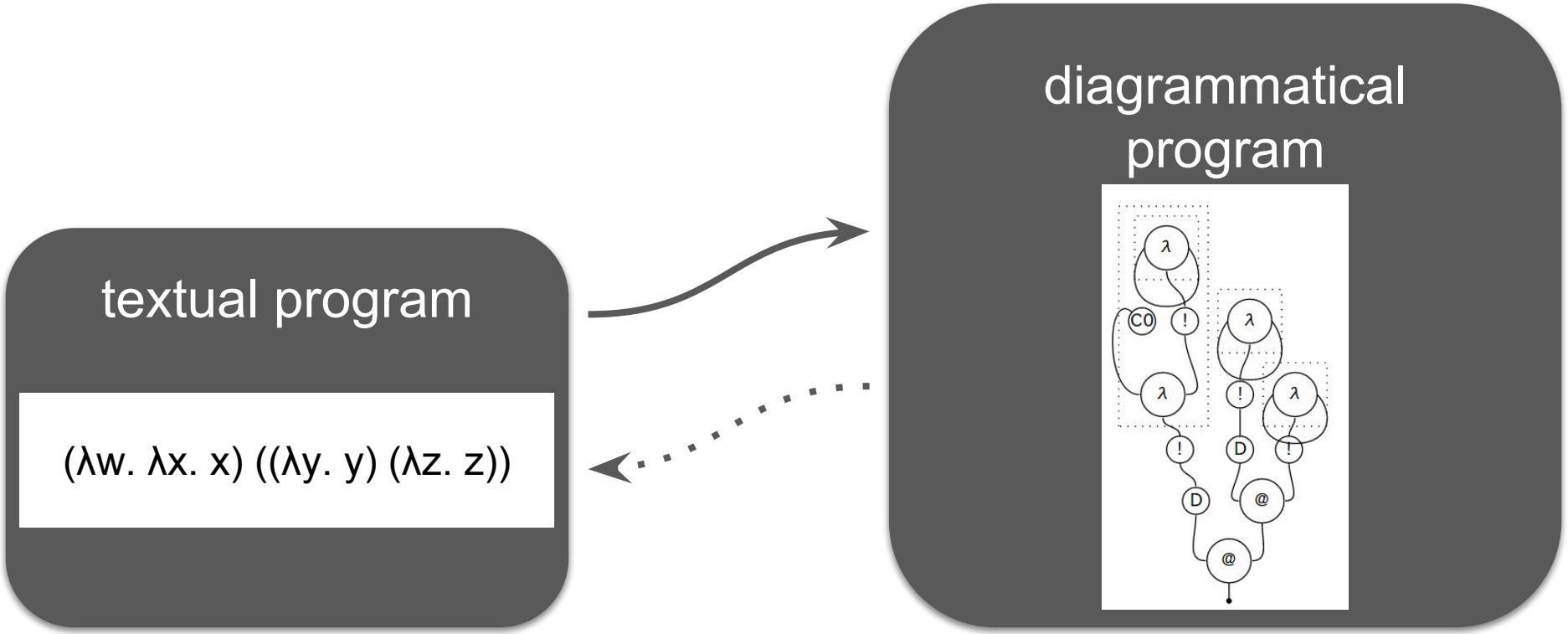
support textual-and-visual programming

guide language design for unconventional/new programming paradigms (to be presented by Steven)

Towards textual-and-visual programming

"We'd like not just text or diagram,
but both!"



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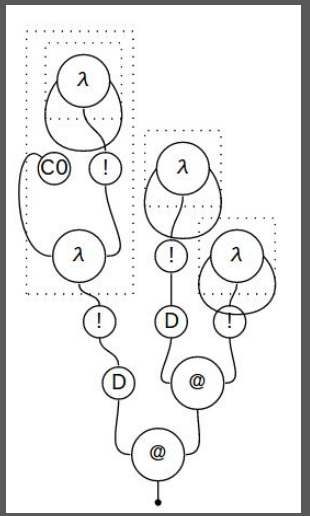
textual program

(λw. λx. x) ((λy. y) (λz. z))

diagrammatical program



✔ (grammar)	form / edit	? (validity criteria)
✔	execute	✔
✔	debug	☐ !

OCaml Visual Debugger

https://fyp.jackhughesweb.com/ by Jack Hughes

for a subset of OCaml

- arithmetic (int), comparison (bool)
- conditional (if), recursion (let rec)
- lists, pairs
- ~~pattern-matching~~

features

- interactive diagram view
- go forwards/backwards & pause/resume & jump steps
- breakpoint on diagram
- stats

OCaml Visual Debugger

visualise interesting properties of programs

- sorting algorithms comparison
  - bubble-sort vs. insert-sort
    https://www.youtube.com/watch?v=bZMSwo0zLio&t=130s
  - merge-sort vs. insert-sort
    https://www.youtube.com/watch?v=U1NI-mWeNe0
- tail-recursion vs. non tail-recursion
  https://www.youtube.com/watch?v=R4yCV5Ts1gk&t=14s

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