Generating Lambda Term Individuals in Typed Genetic Programming Using Forgetful A*

Tomáš Křen, Roman Neruda

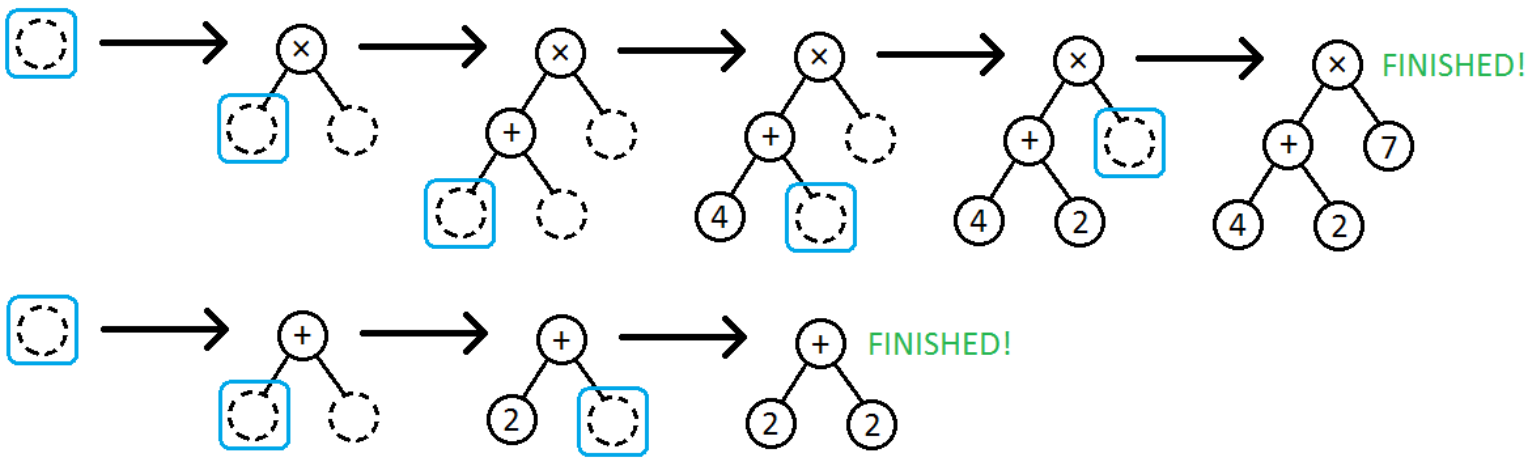
Charles University, Faculty of Mathematics and Physics &
Institute of Computer Science, Academy of Sciences of the Czech Republic

Presentation outline

- Standard population generating vs..
- Exhaustive enumeration
- Less exhaustive (more random) enumeration
- Generalization for *simply typed lambda calculus*
- Experiments

Standard generating procedure

- works in separate iterations
  - In each iteration one tree individual is generated.



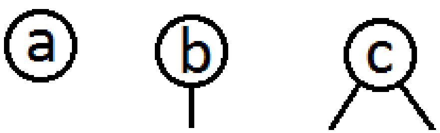
- We can do this differently:
  - “Generating of shared parts can be shared.”

Exhaustive enumeration

- Systematic population generating
  - From smallest to biggest tree
- We use A* algorithm
- Let's see an example

Exhaustive enumeration

INPUT



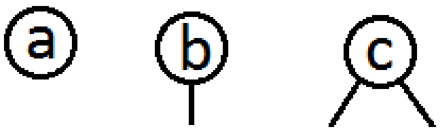
e.g. T = {a}, F = {b:1 arg, c:2 args}

PRIORITY QUEUE

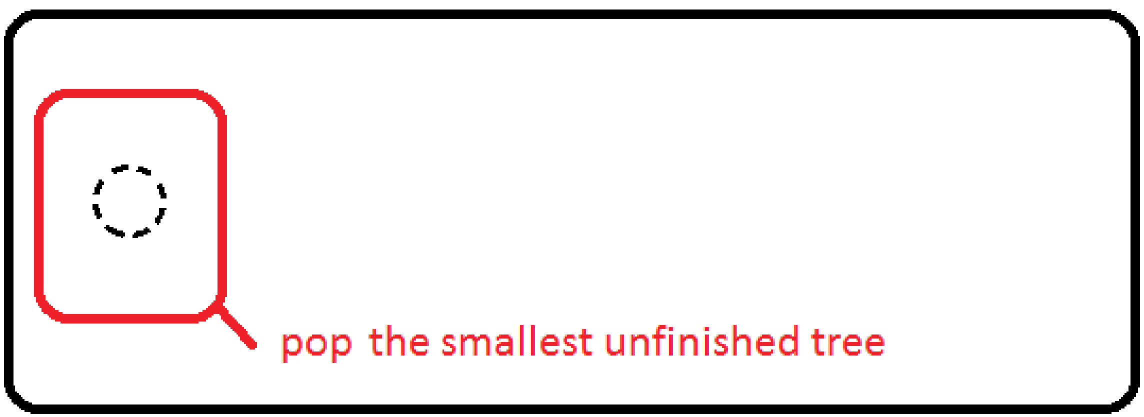
OUTPUT

Exhaustive enumeration

INPUT

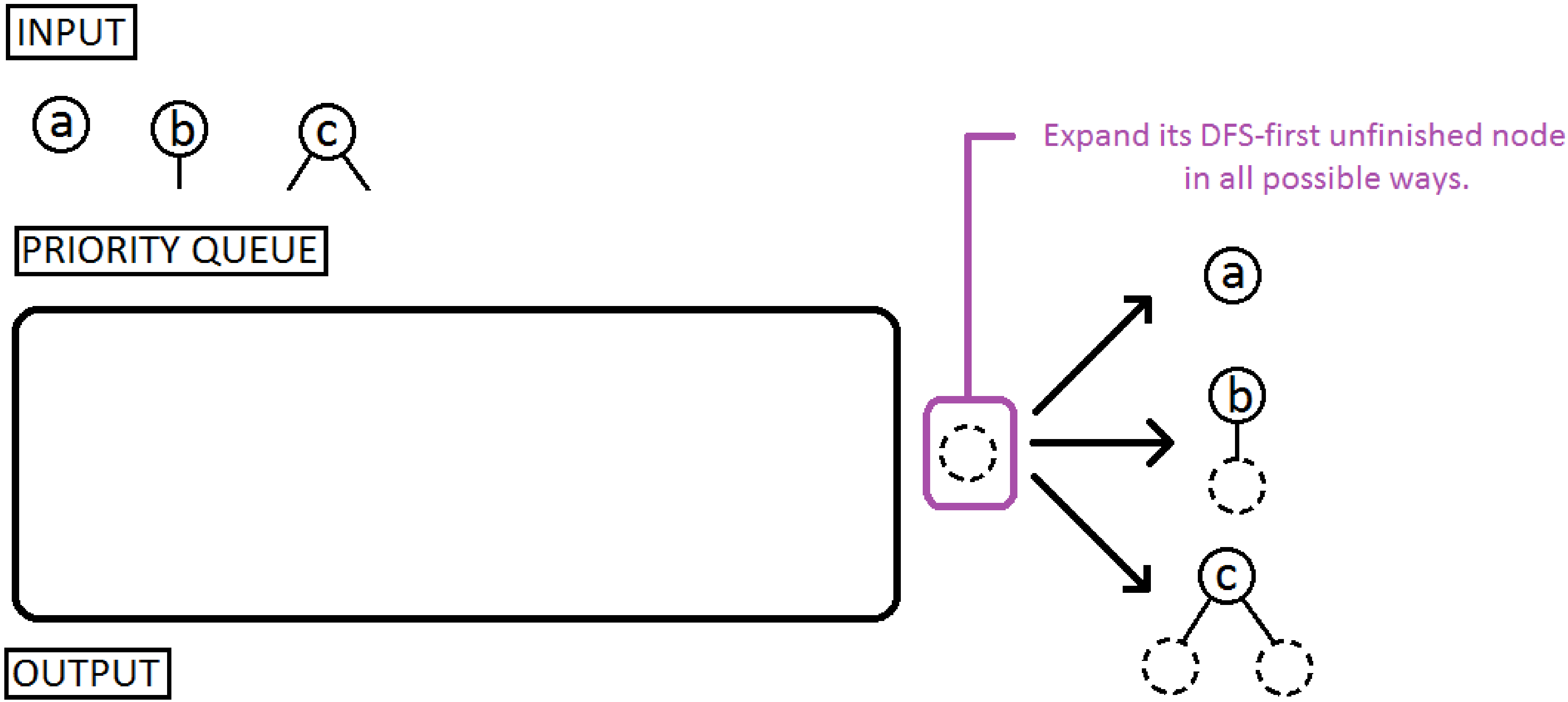


PRIORITY QUEUE

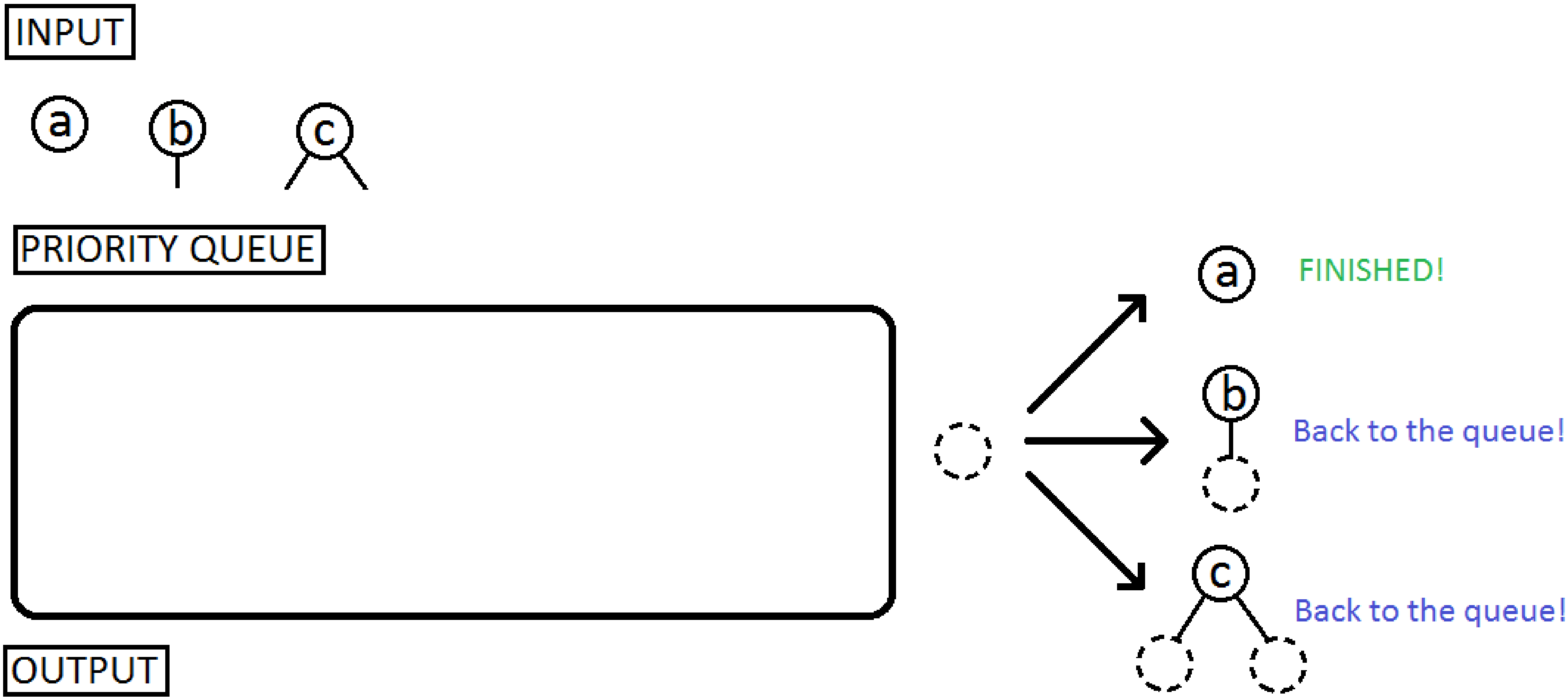


OUTPUT

Exhaustive enumeration



Exhaustive enumeration



Exhaustive enumeration

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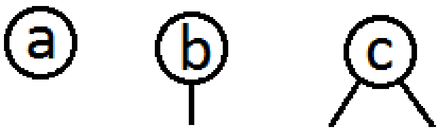

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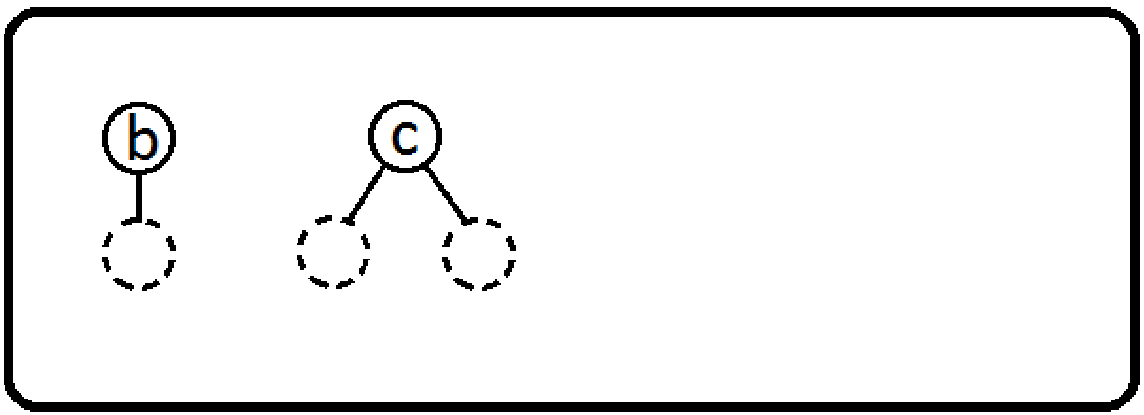

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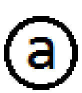

Exhaustive enumeration

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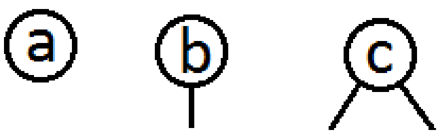
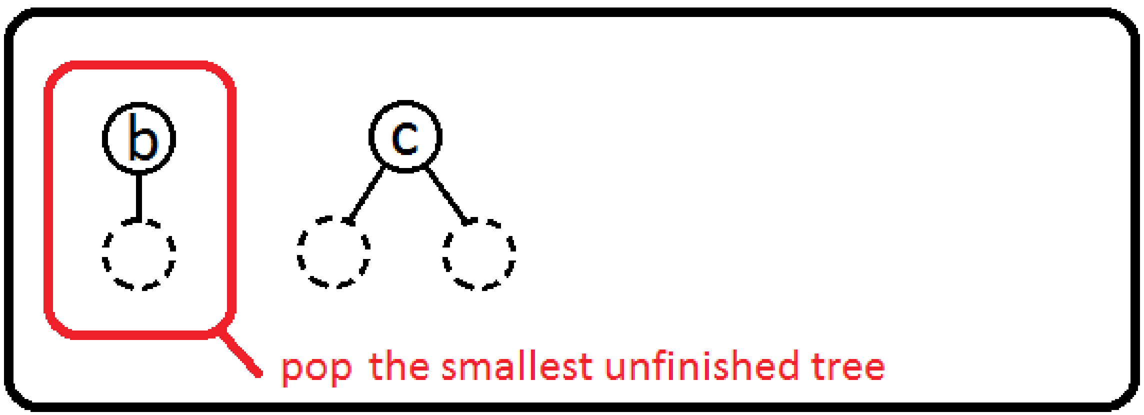


PRIORITY QUEUE



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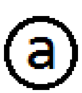
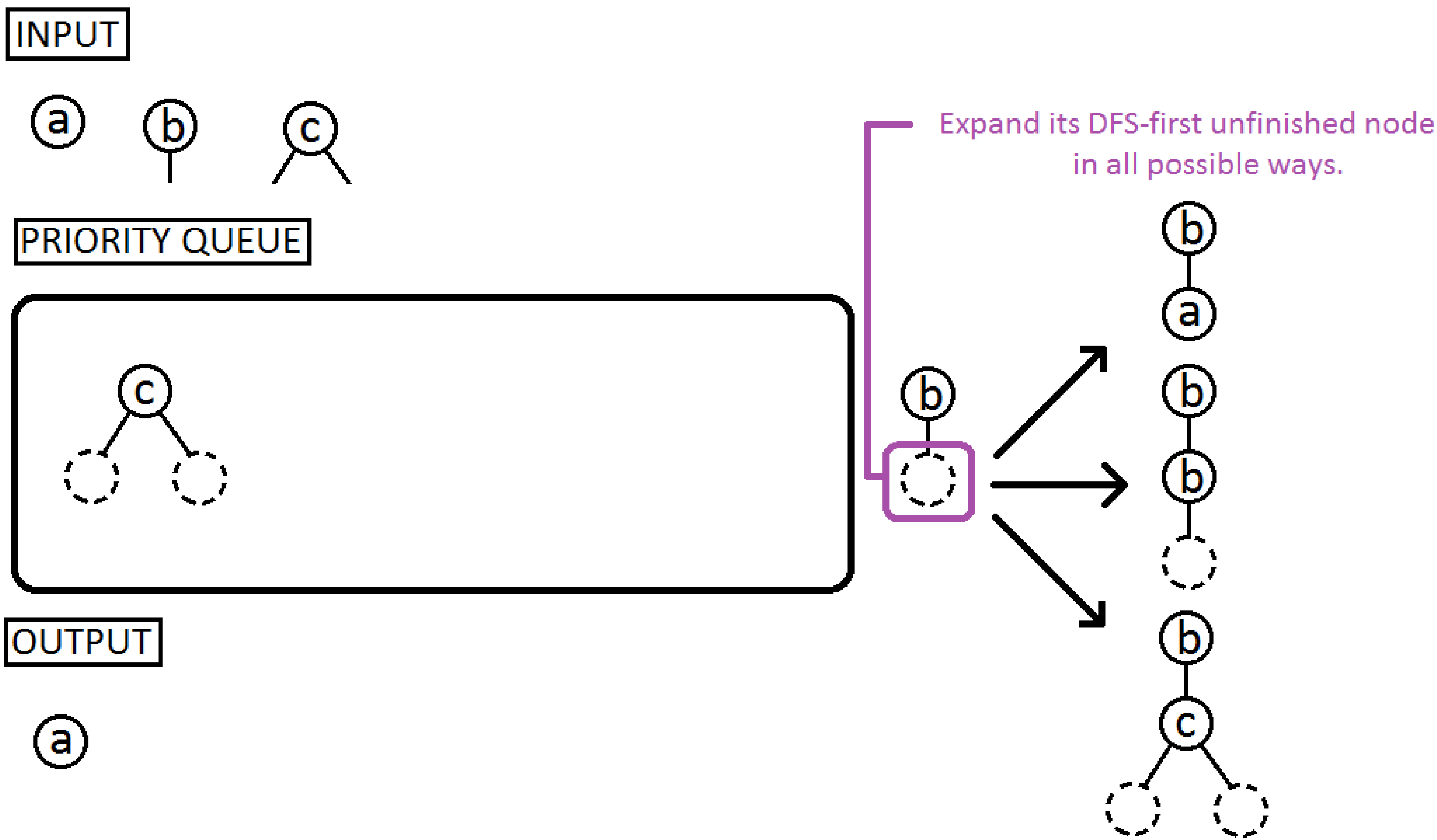
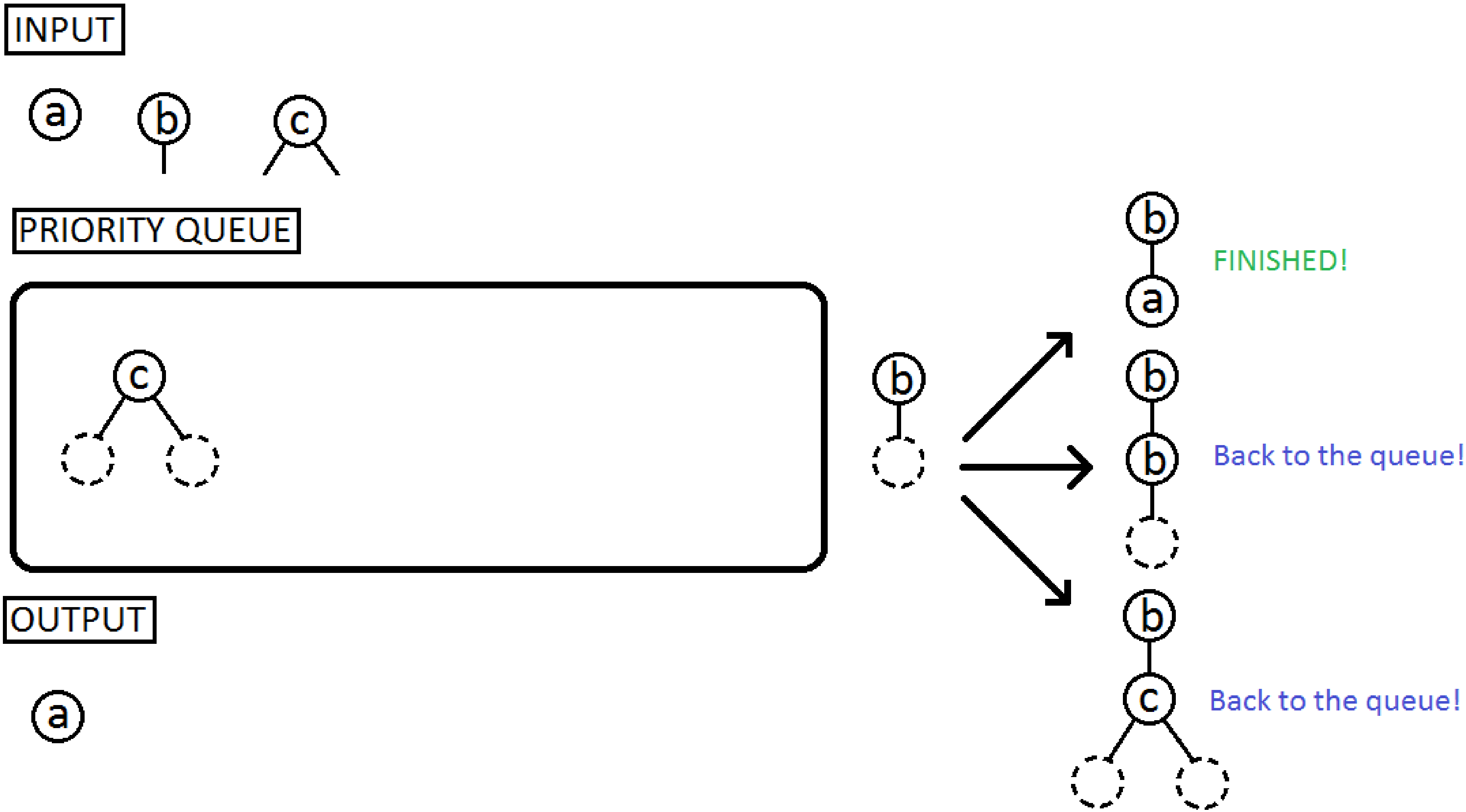


Exhaustive enumeration



Exhaustive enumeration



Exhaustive enumeration

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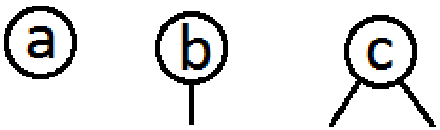

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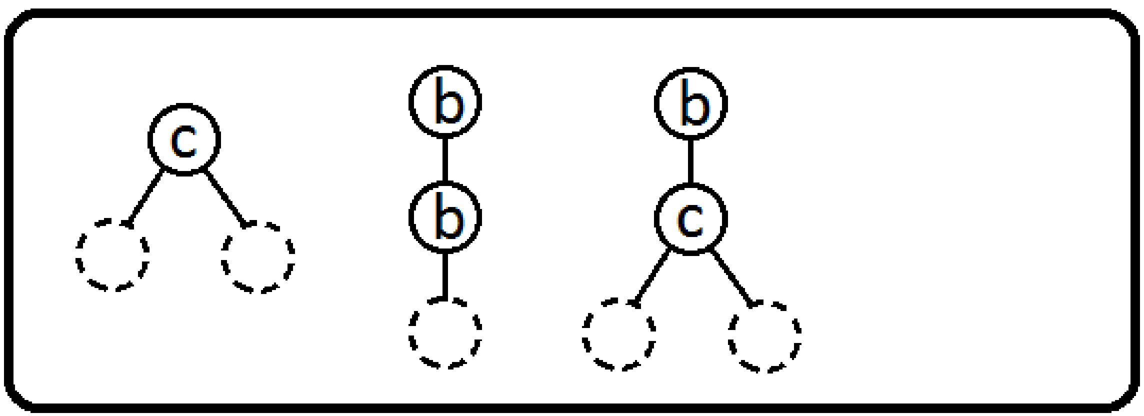

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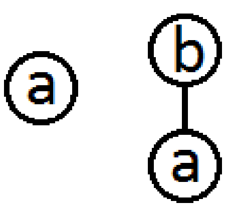
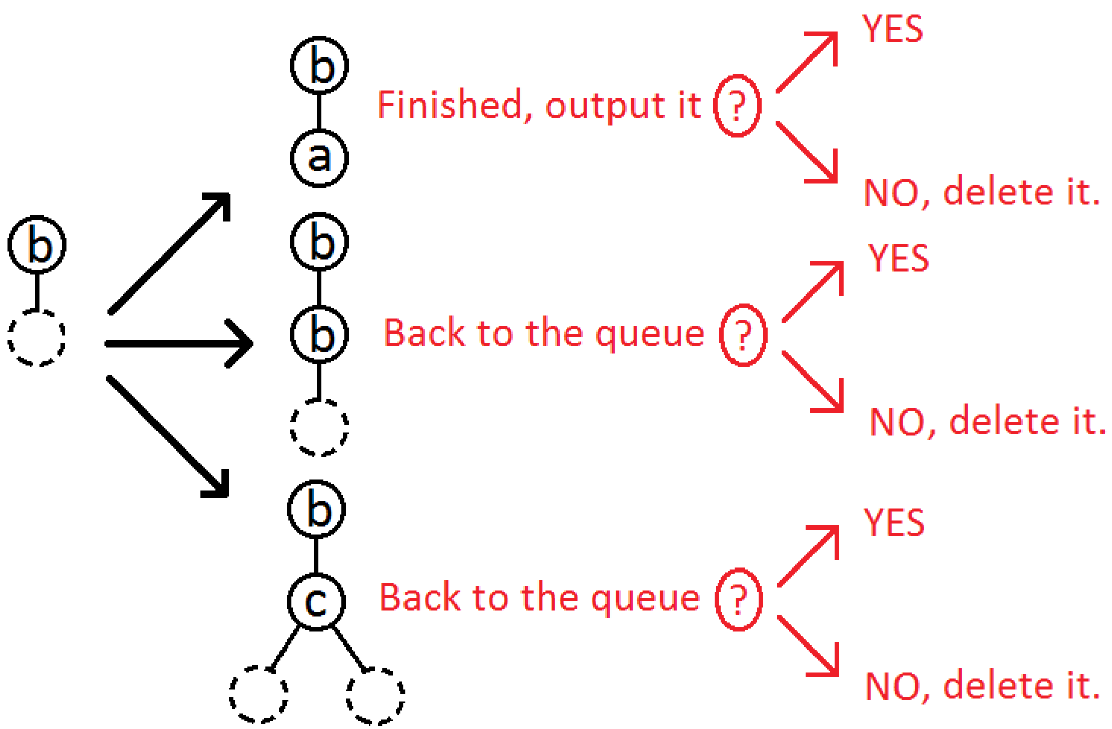


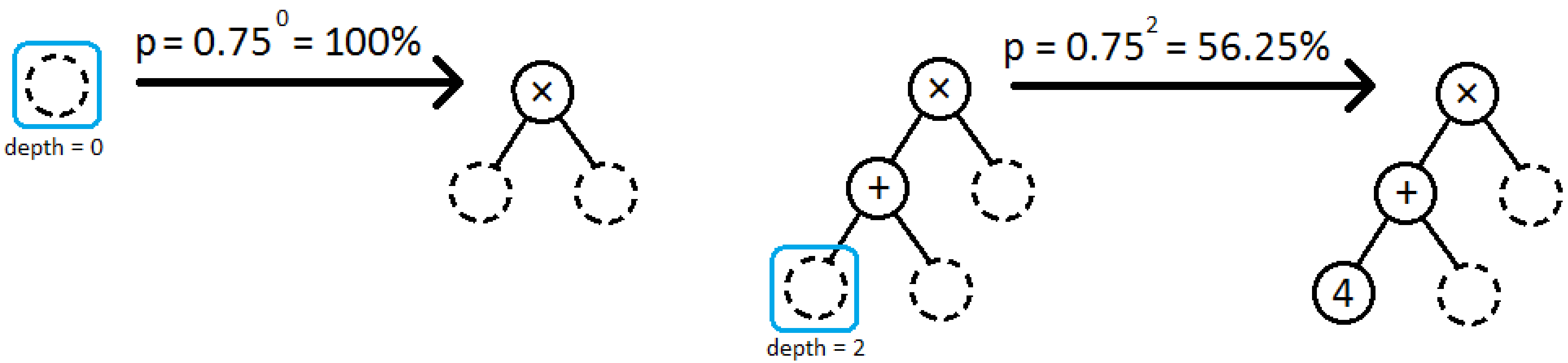
How to make enumeration more random?

- We add a new step deciding what to do with an expanded tree:
  - keep it,
  - or delete it?
- We call this additional decision procedure a *generating strategy.*
  - *"Keep all"* strategy = exhaustive enumeration
  - *"Delete all but one"* strategy = standard generating approach



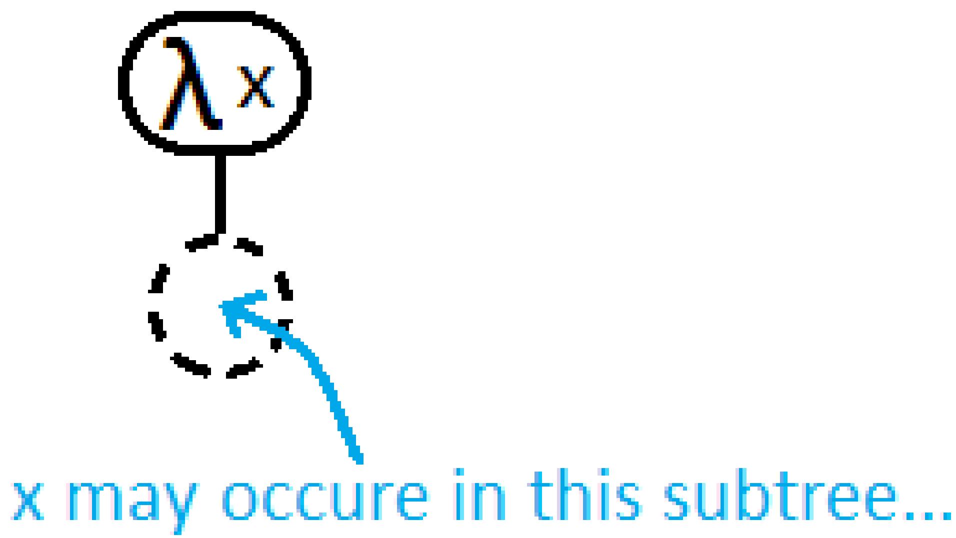
Our *geometric* strategy

- It puts an expanded tree back to the queue with probability $\mathbf{p = q^{depth}}$
- Where **q** is a constant, we used **q = 0.75**
- And **depth** is depth of the expanded node



Lambda calculus

- Simple yet powerful (mathematical) programming language
- It uses anonymous functions very often.
  - (λ x . <*function body, where x may occur*>)

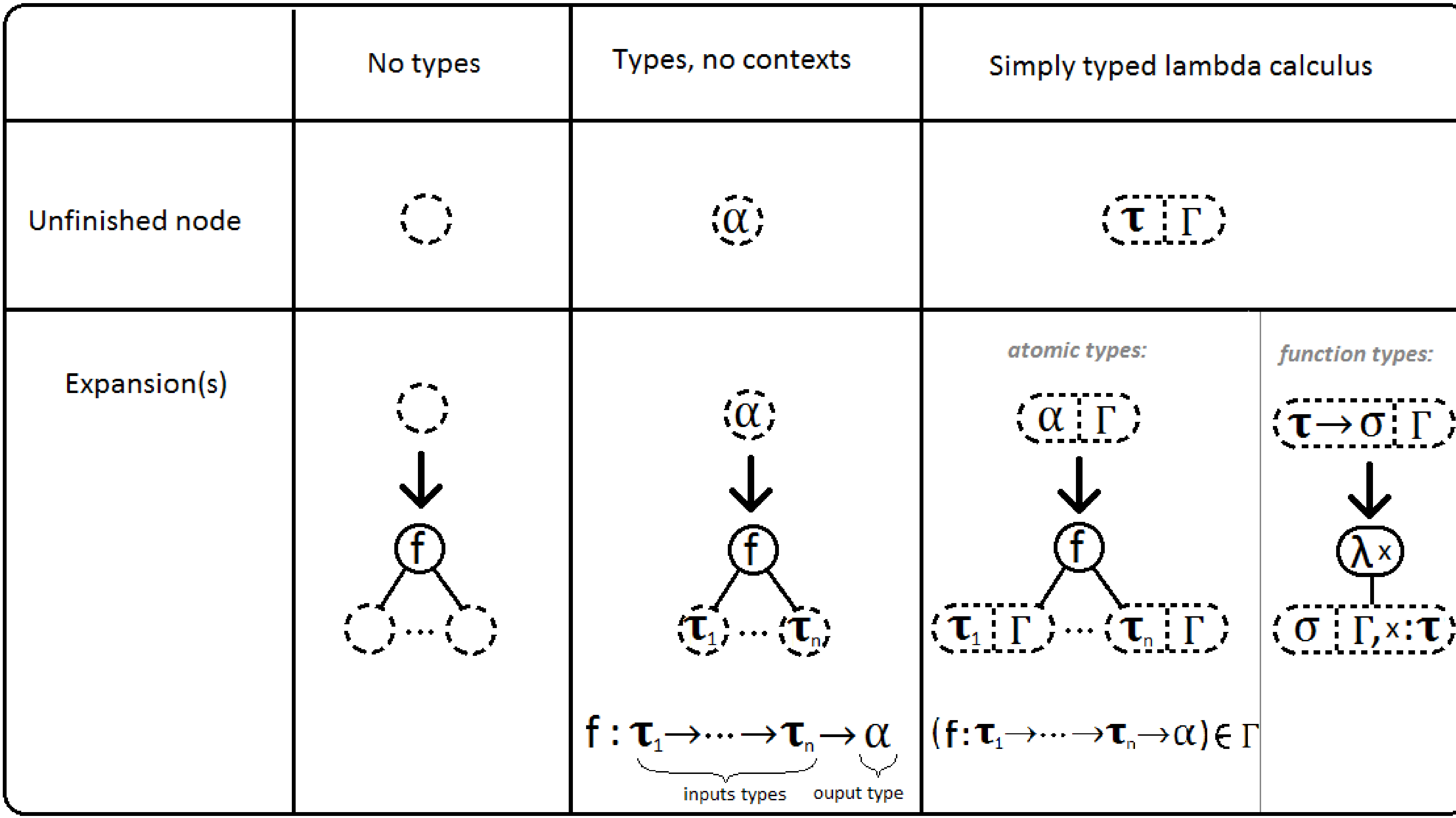


Types

- Types help us overcome the *closure requirement*.
- But also make the programs more reasonable.

- (Local) context (usually denoted as Γ)
  - Set of symbol names accompanied with types
  - “$\mathbf{T} \cup \mathbf{F}$ is an initial/global context”
  - We can add local variables to a context

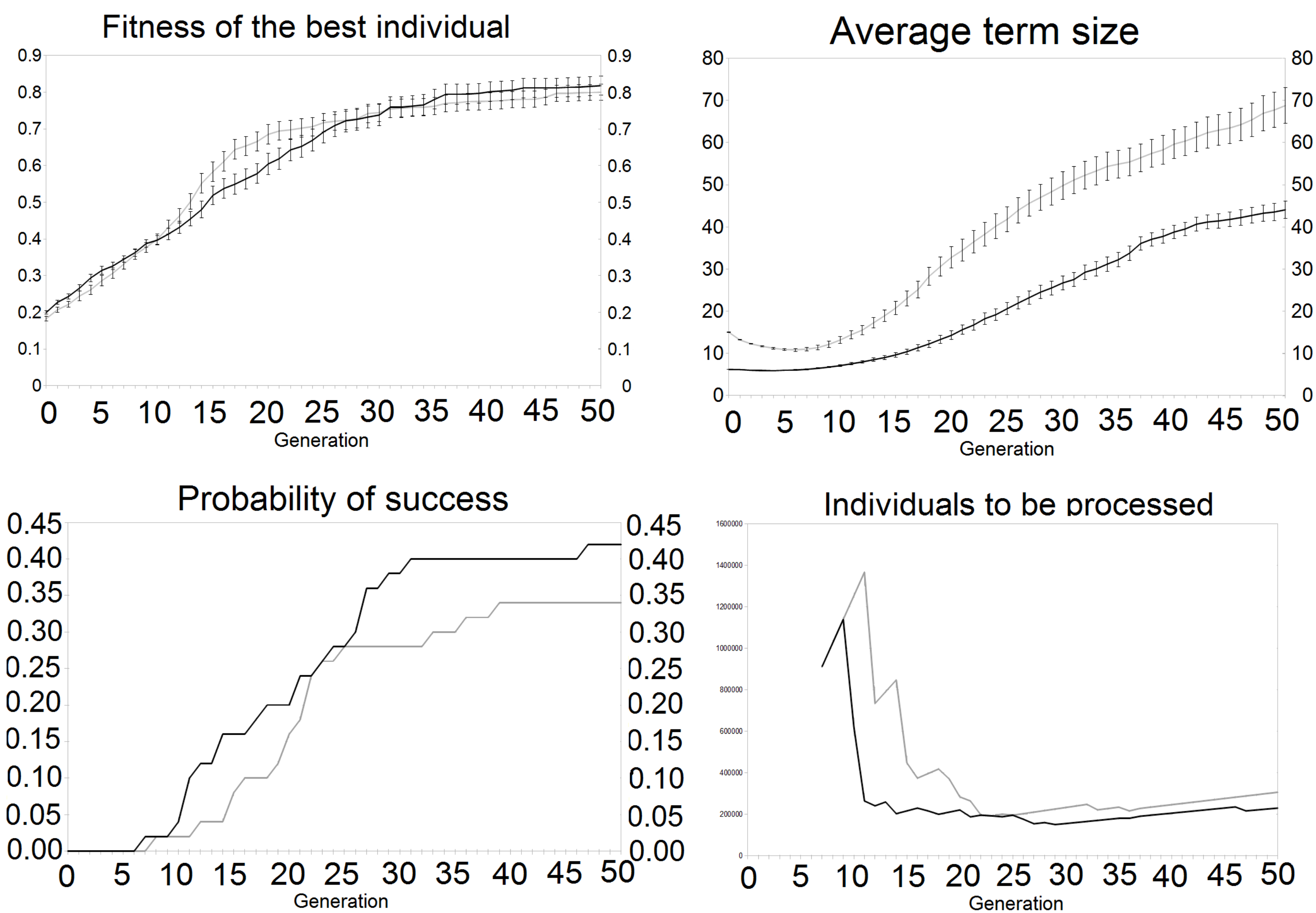
Generalization for simply typed lambda calculus



Experiments

- We compared performance of our *geometric* strategy with standard *ramped half-and-half* on 3 benchmark problems.
- 50 runs, 500 population size, 51 generations
- Metrics
  - Average fitness of the best individual
  - Average term size
  - Cumulative probability of success
  - Number of individuals that must be processed to yield a correct solution with probability 99%
  - Time

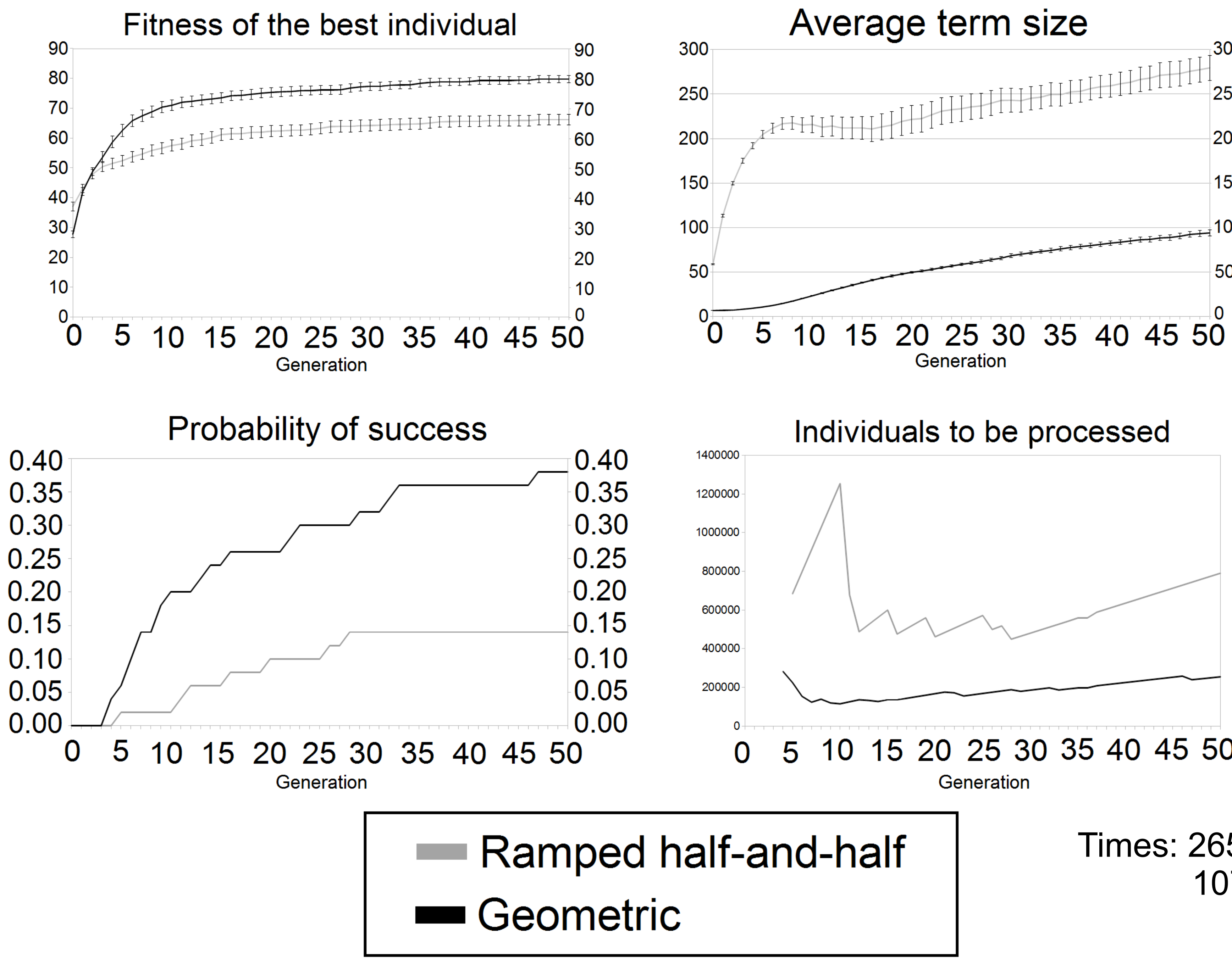
Simple symbolic regression



Ramped half-and-half
Geometric

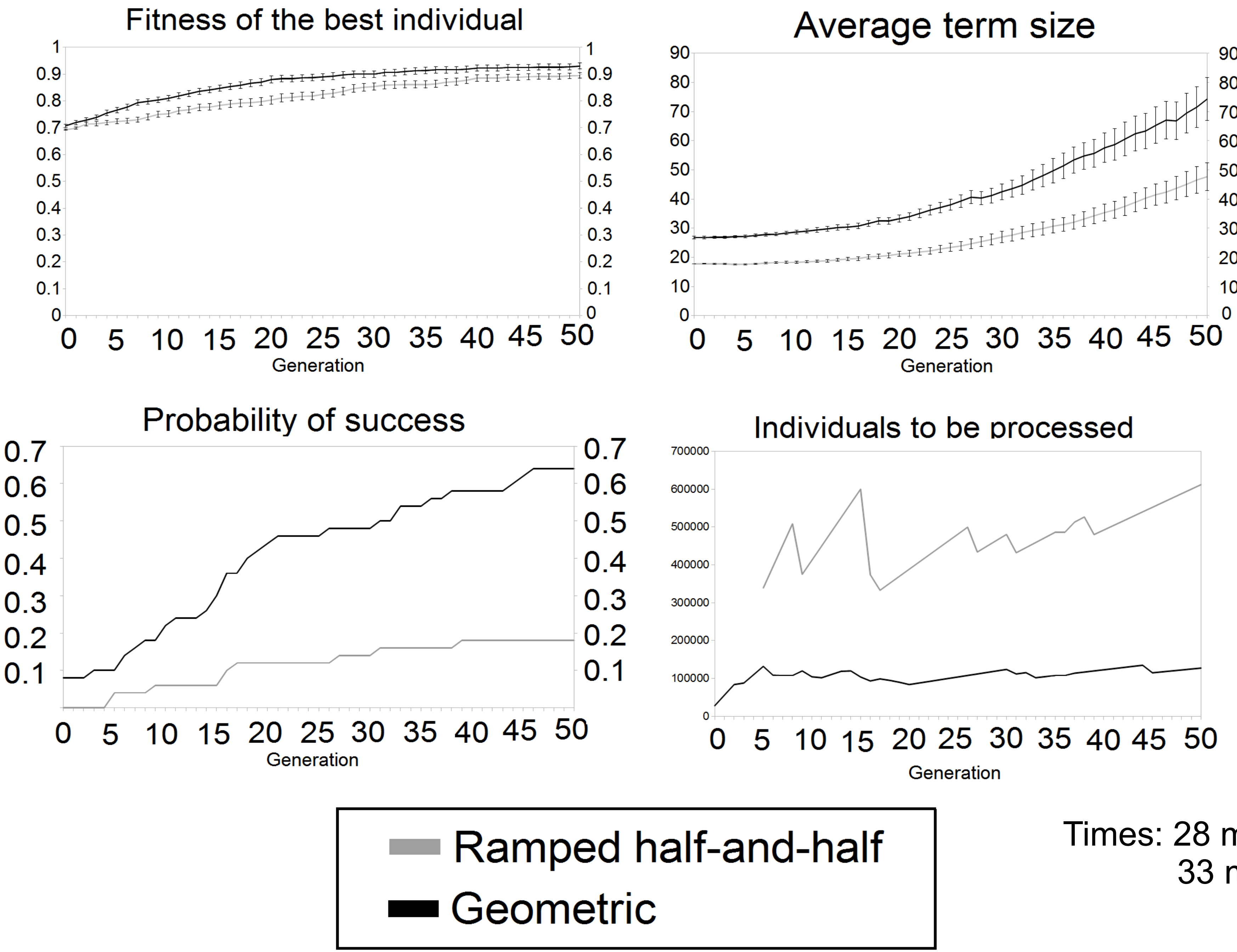
Times: 46 minutes
26 minutes

Artificial ant problem



Times: 265 minutes
107 minutes

Even parity problem



Times: 28 minutes
33 minutes

Conclusions

- *Geometric* outperforms standard *Ramped half-and-half*
- It seems that it reduces bloat.
- Works nicely with types.
- Future work
  - More test problems
  - Stronger type systems
  - Meta-evolution of generating strategy

Thank you for your attention!

Any questions?

tomkren@gmail.com
roman@cs.cas.cz