2016.08.23

Open Problems from my perspective

INDIANA UNIVERSITY

Our group (last 3 years)

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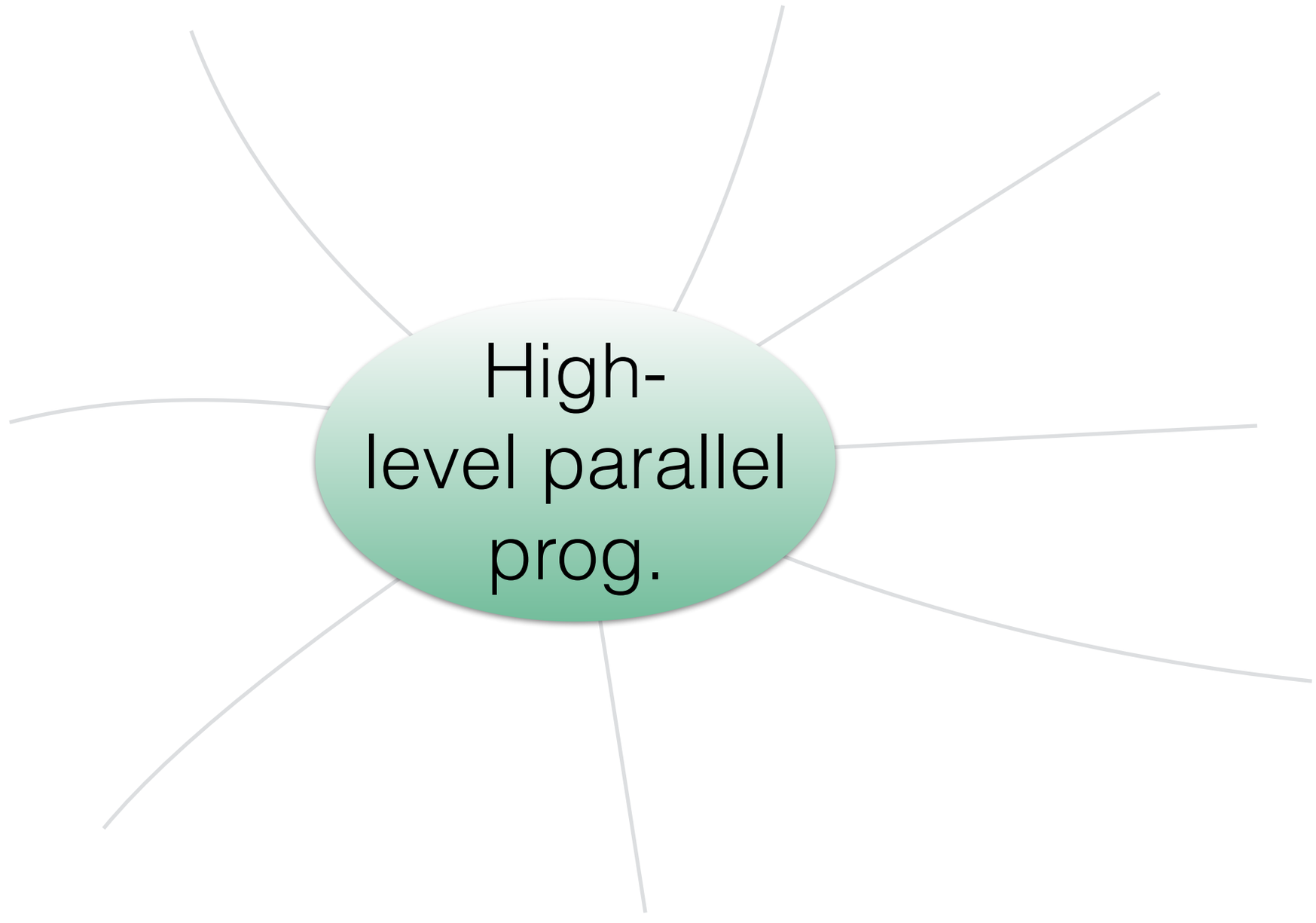

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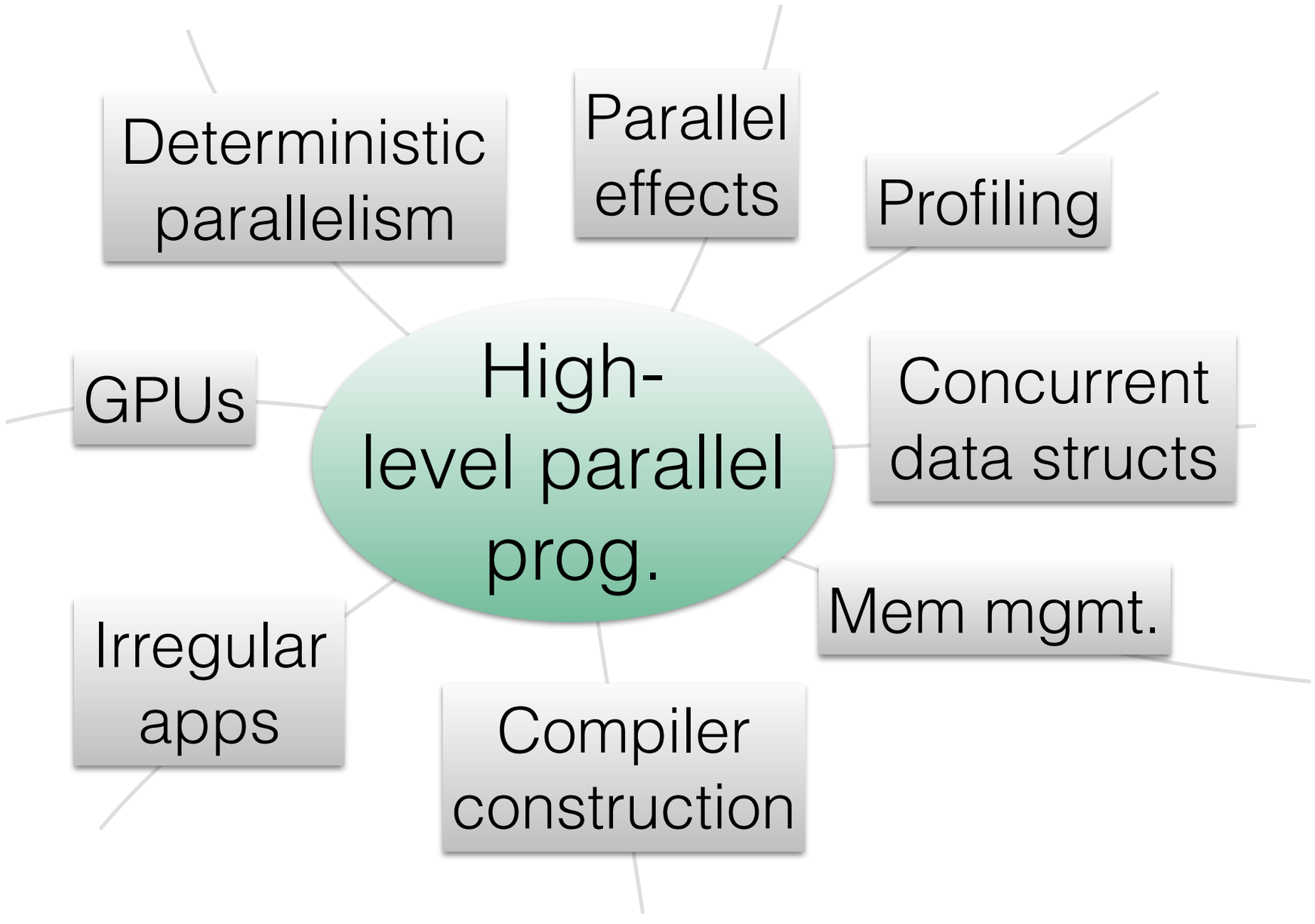

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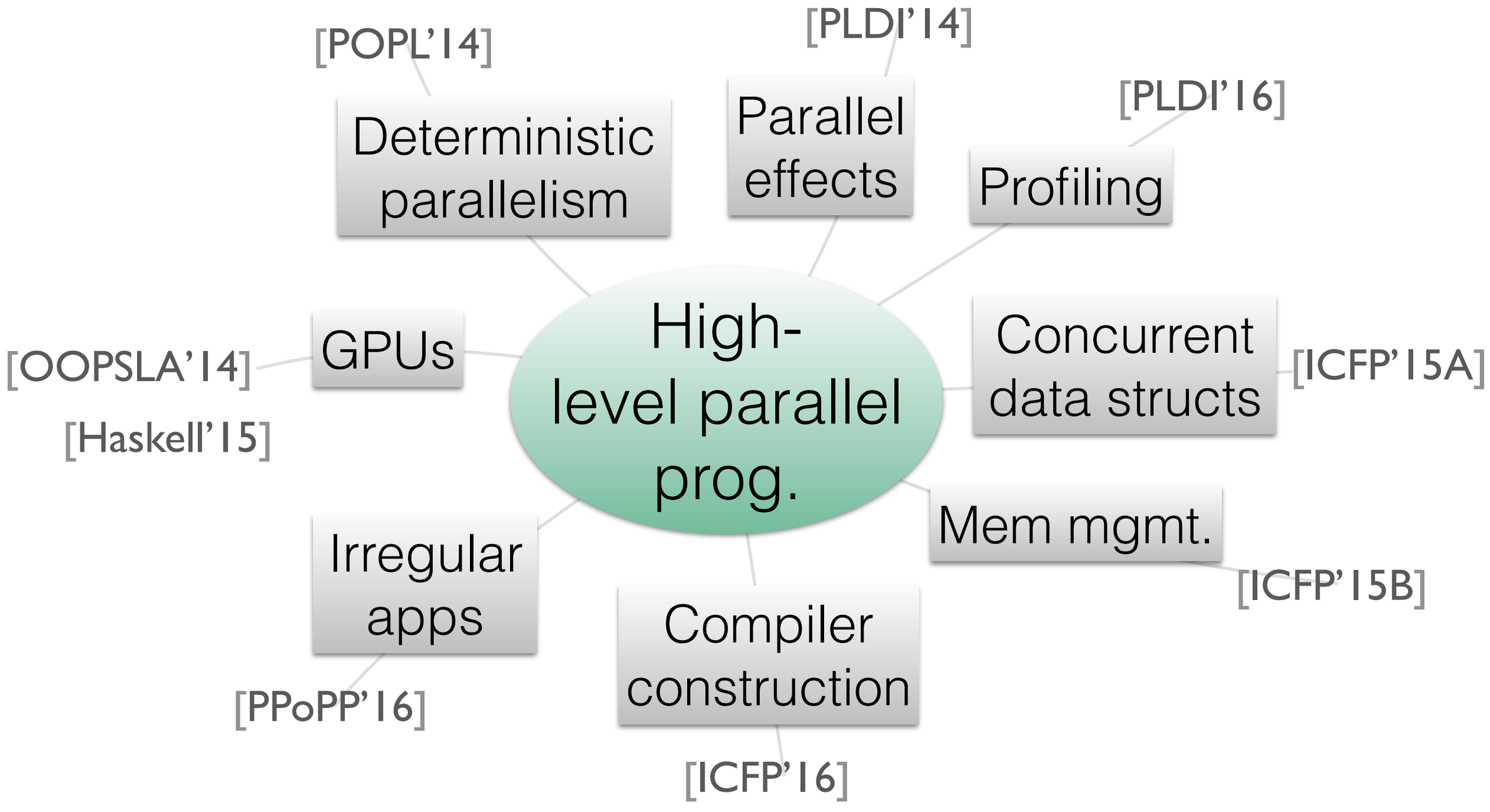

1. Archival-quality computation

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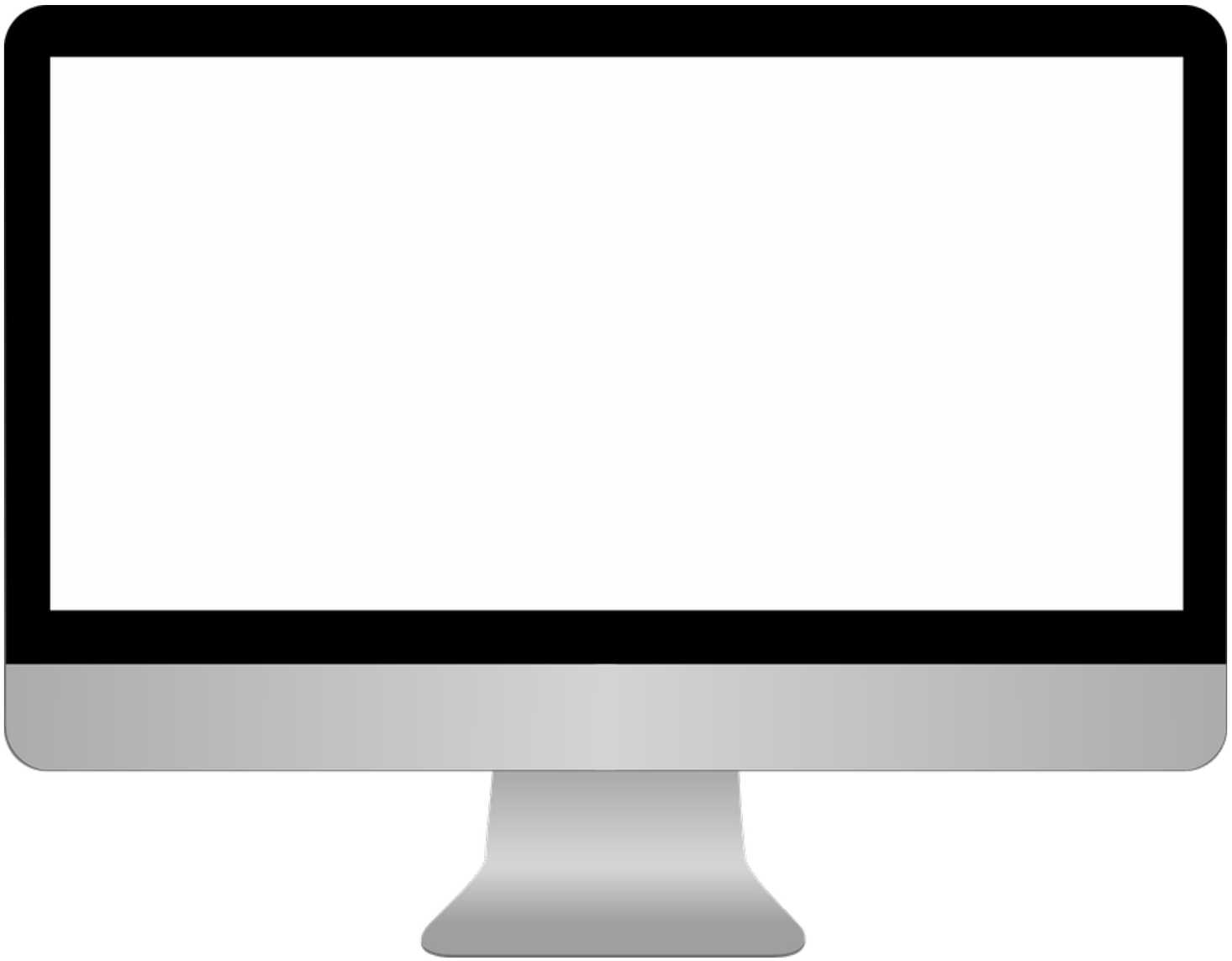

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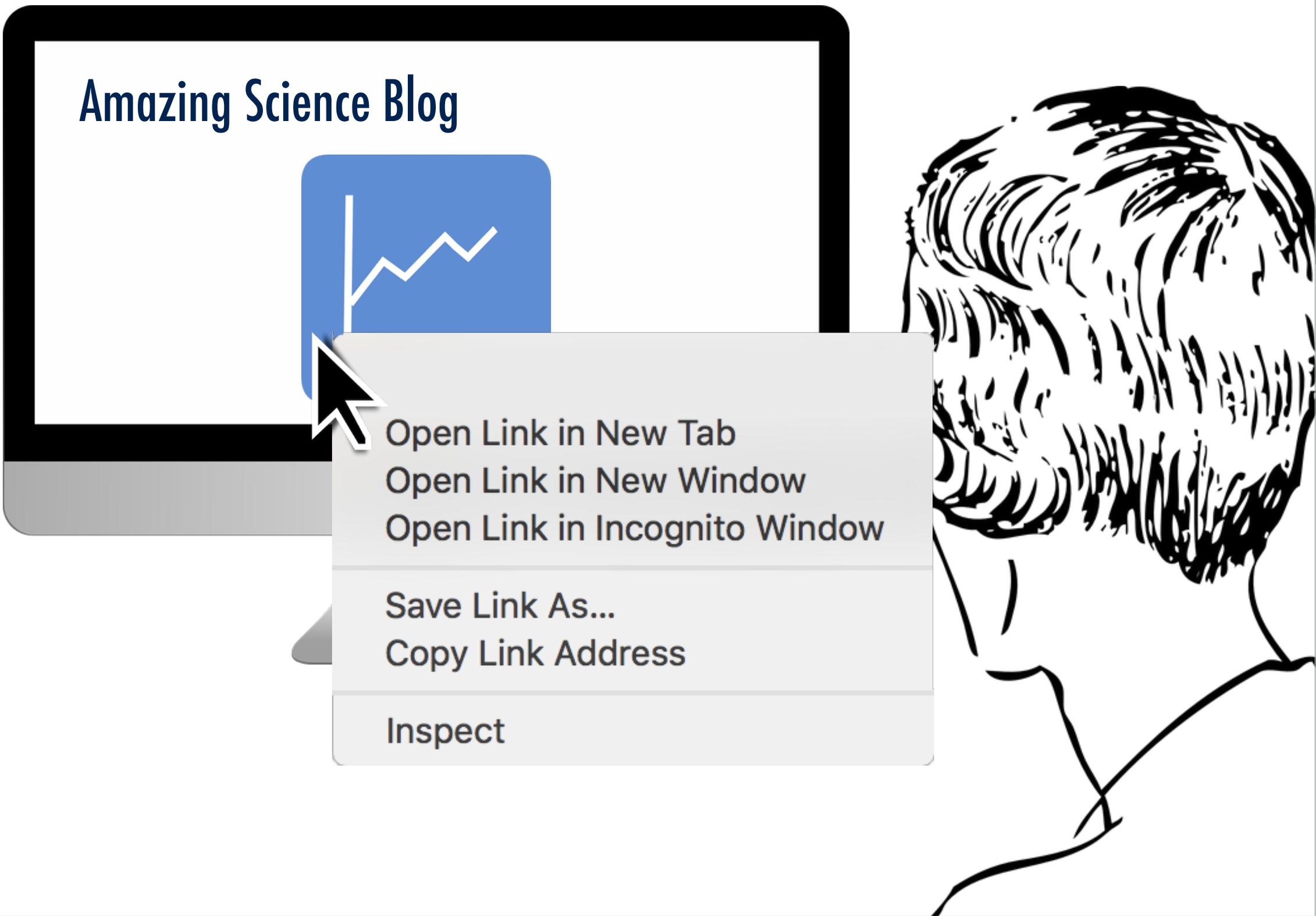

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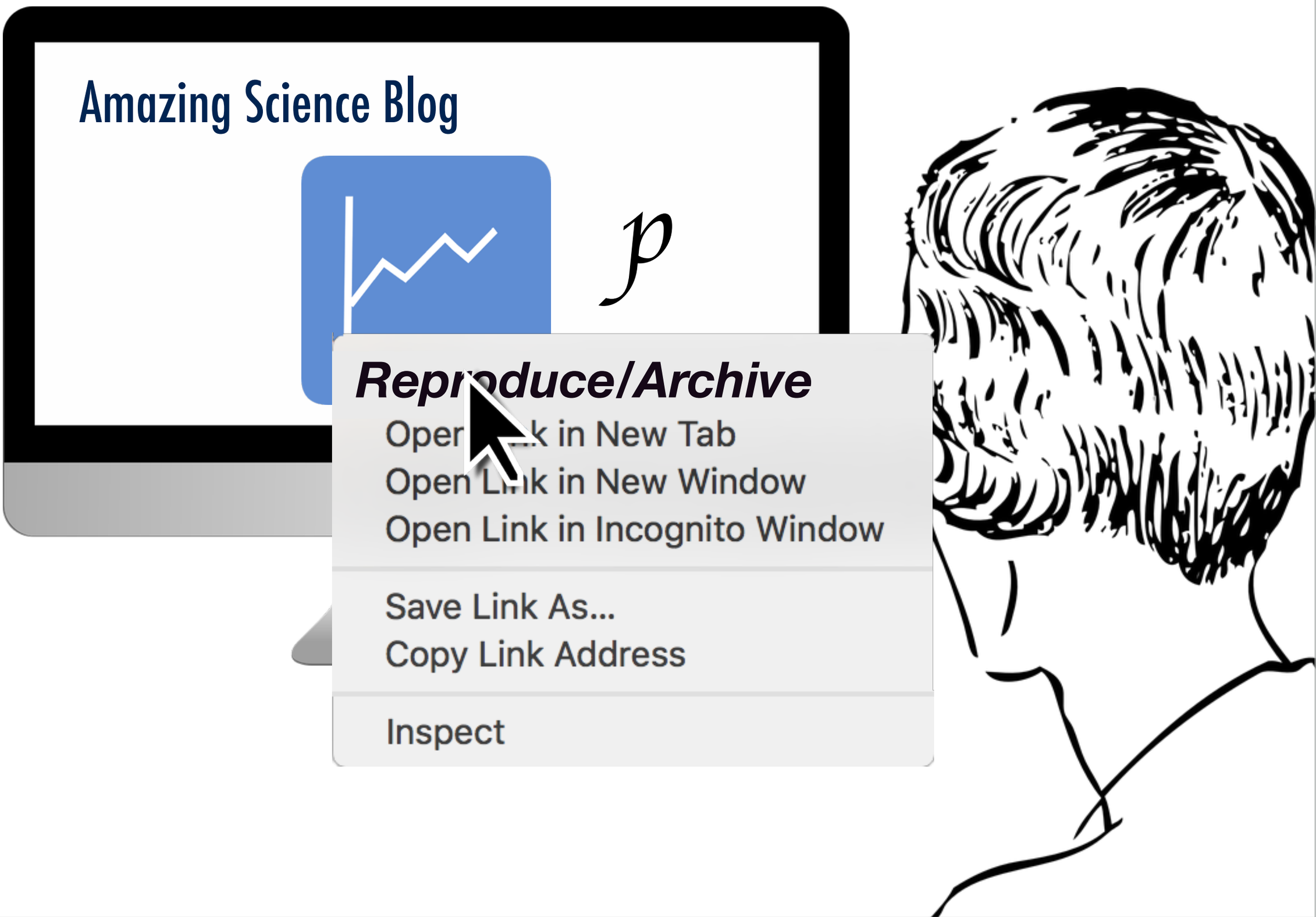
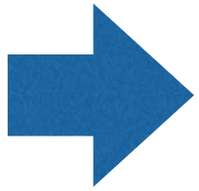
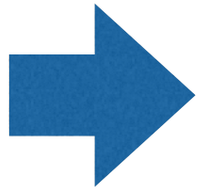


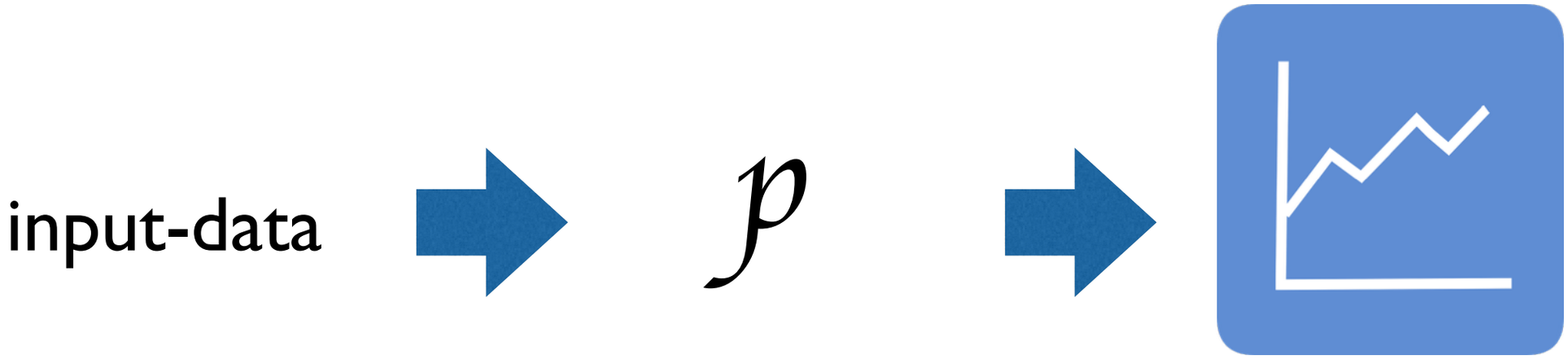
$$\mathcal{p}$$

input-data

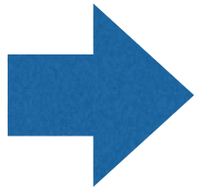
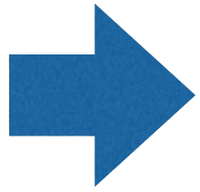


$\mathcal{P}$





Determinism Enforcement

input-data  $\mathcal{P}$  

Determinism Enforcement

<u>control</u>

- Environment

input-data → $\mathcal{P}$ → 

Determinism Enforcement

control

- Environment
- Execution

input-data → $\mathcal{P}$ → 

Determinism Enforcement

control

- Environment
- Execution
  - dynamic

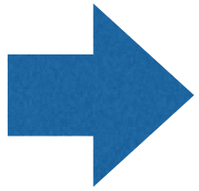
input-data → $\mathcal{P}$ → 

Determinism Enforcement

<u>control</u>

- Environment
- Execution
  - dynamic
  - static

input-data



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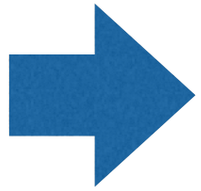

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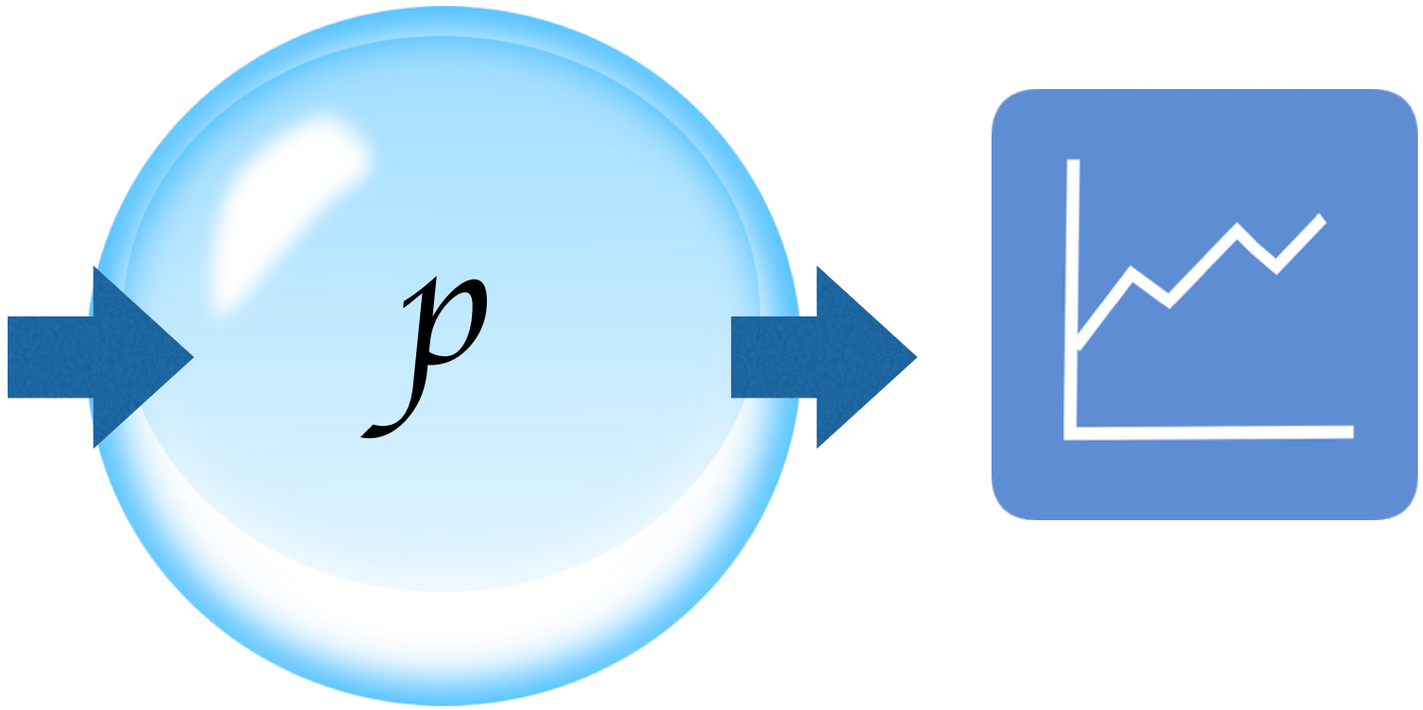

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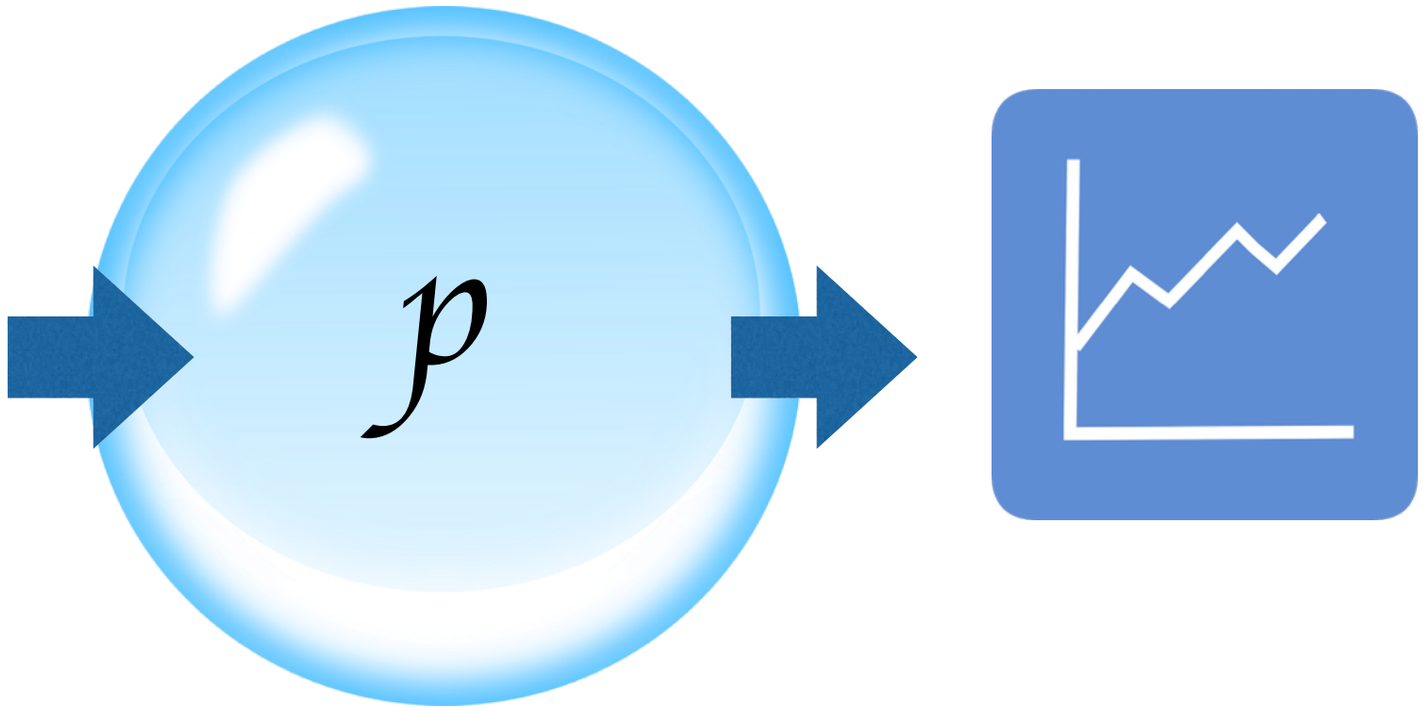
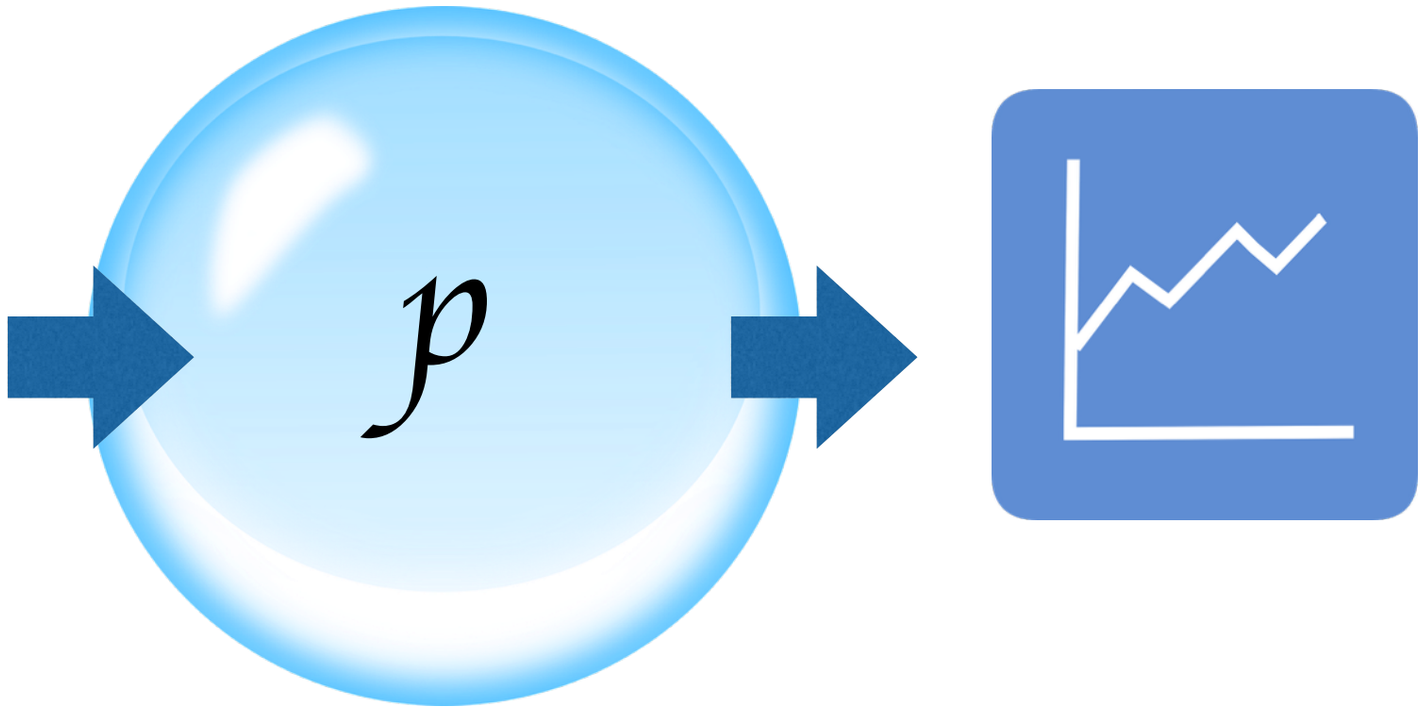


Deterministic base image

Environment:

input-data



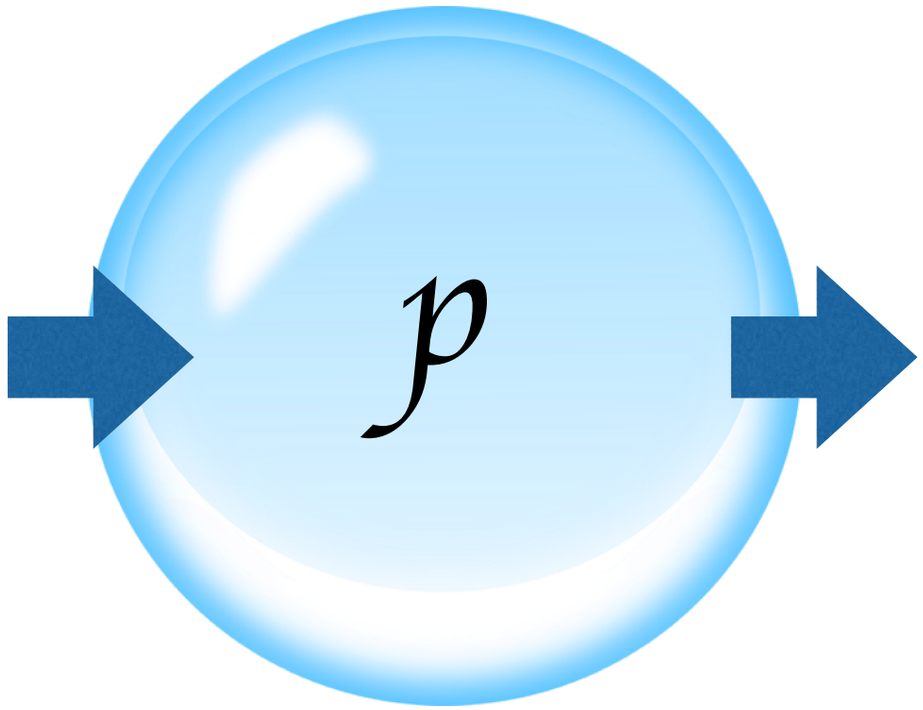
Deterministic base image

docker

NixOS

Execution:

input-data



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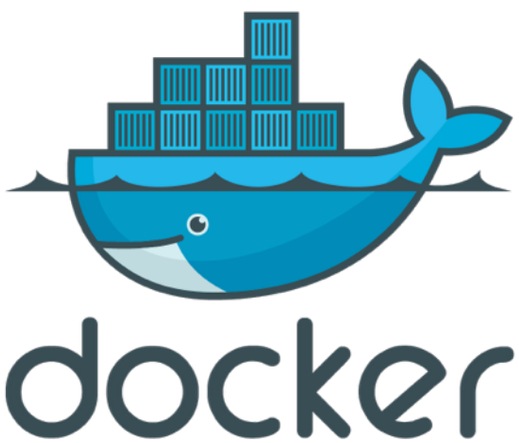

Execution:

p

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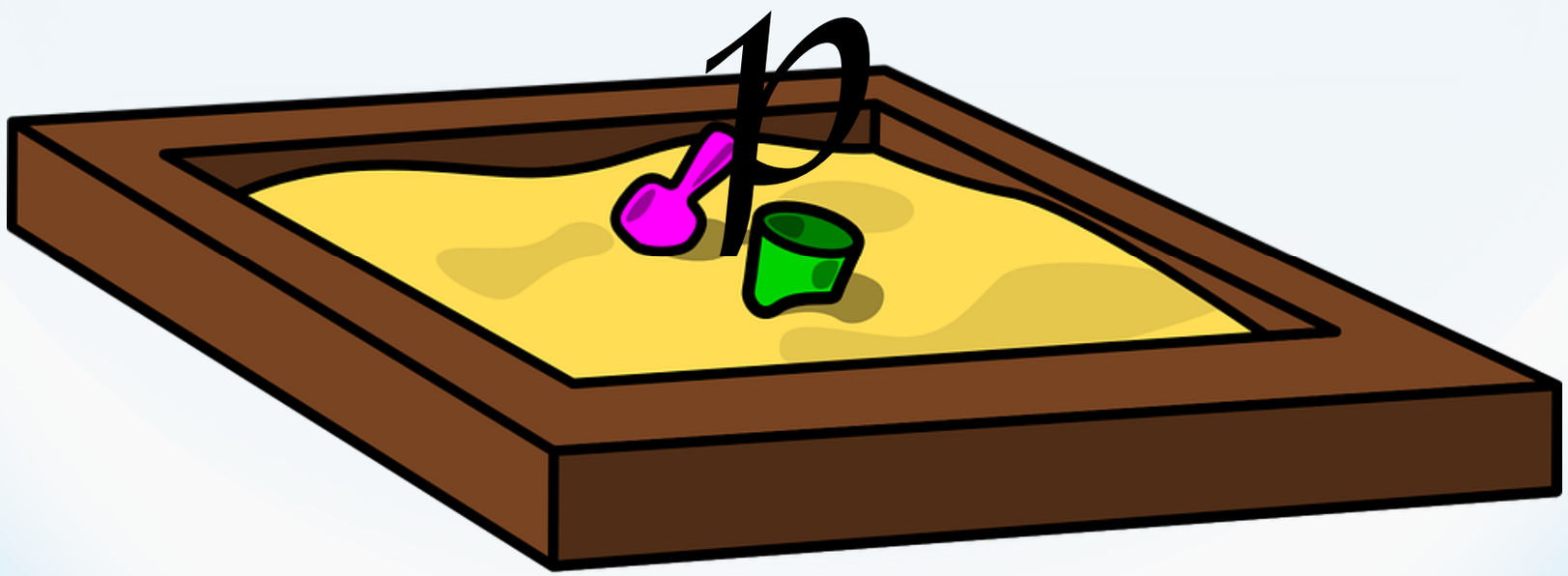
p

Dynamic determinism enforcement



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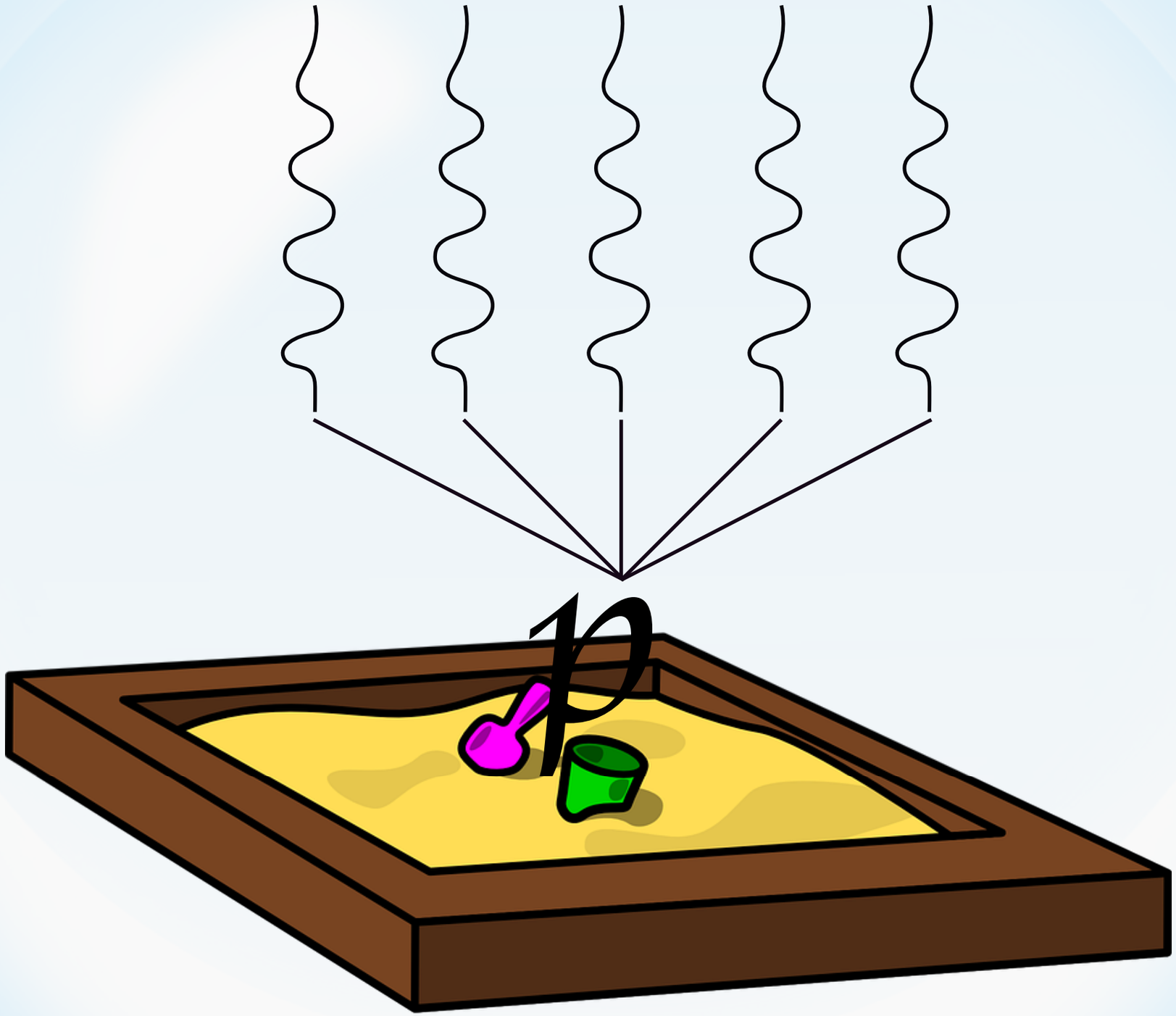

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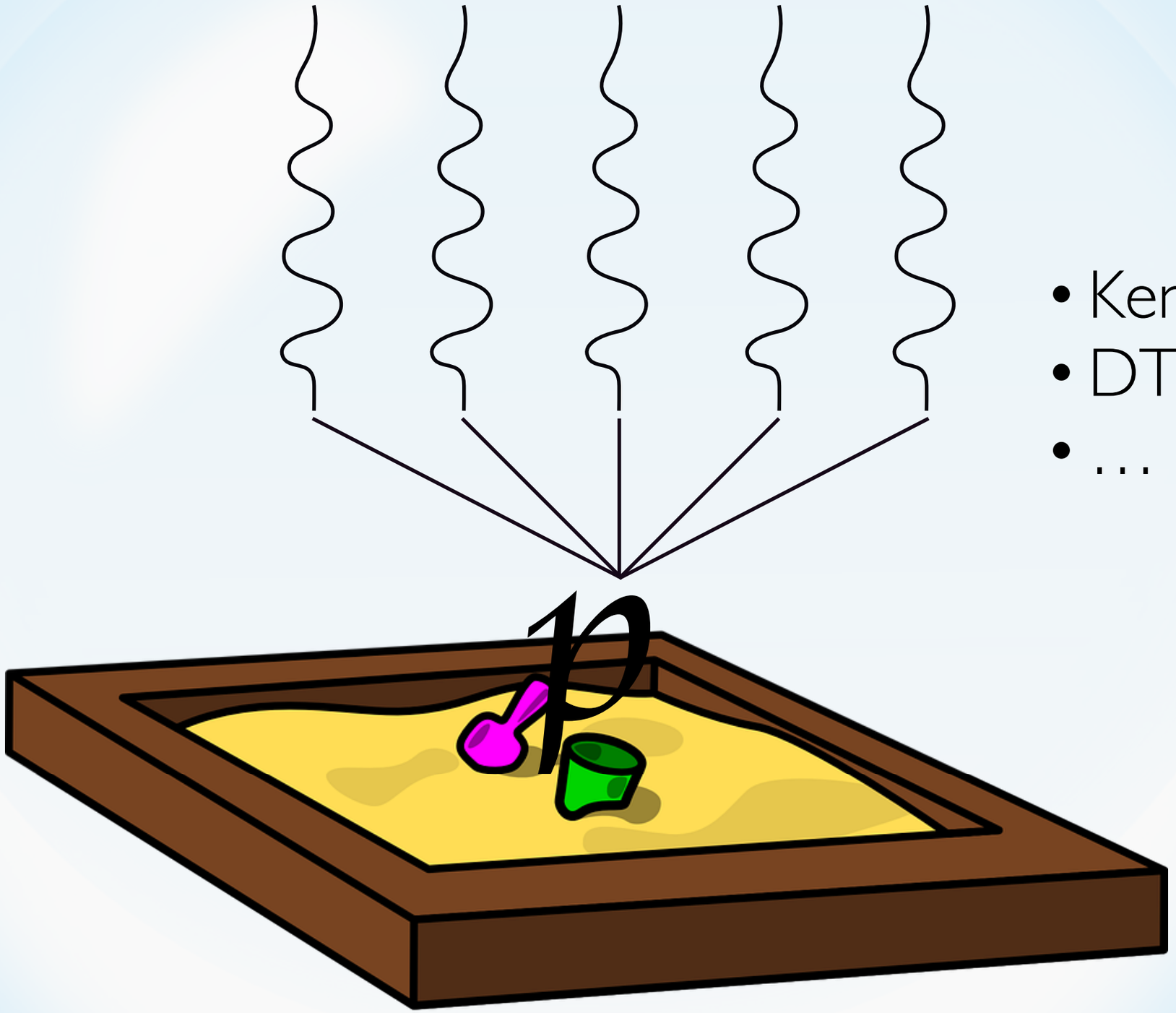
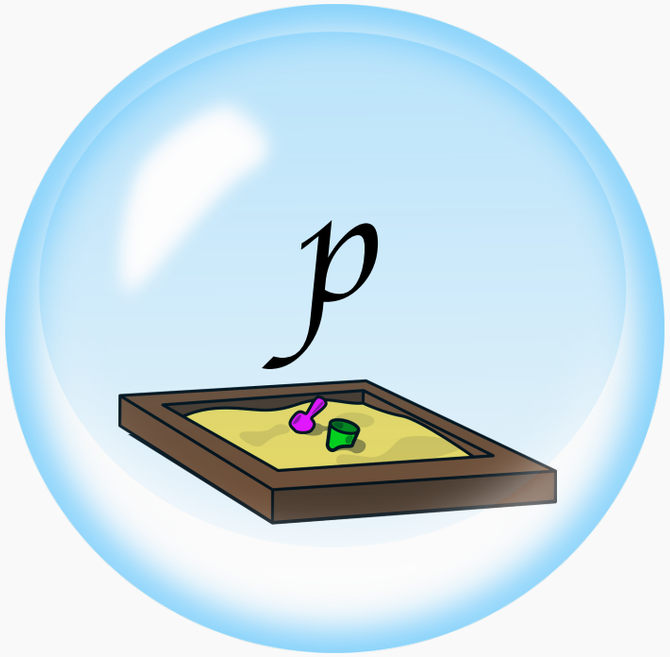
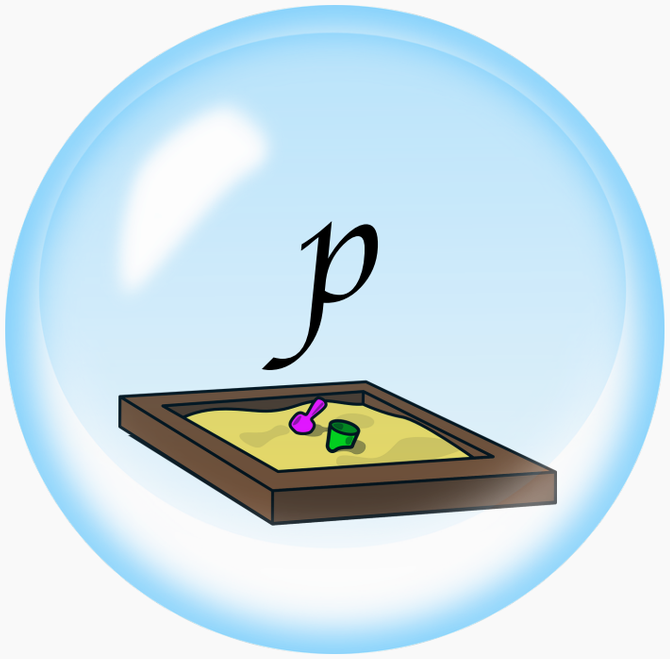


- Kendo
- DThreads
- …

Dynamic determinism enforcement



: (Inputs , NumThreads) → Outputs



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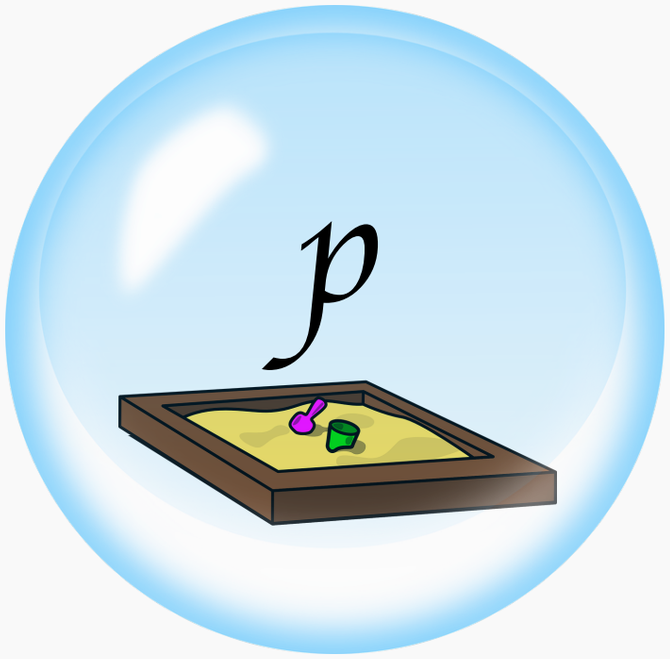
Reproducibility



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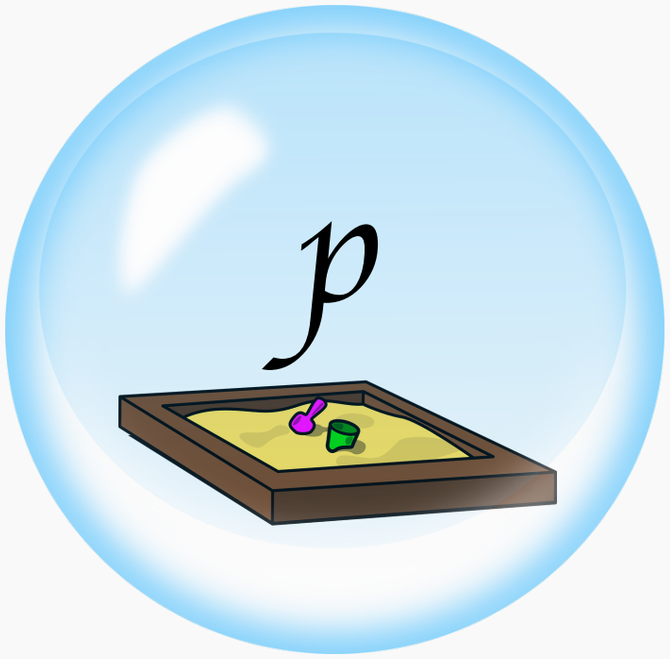
Portability



: (Inputs , GPU model) → Outputs

Reproducibility

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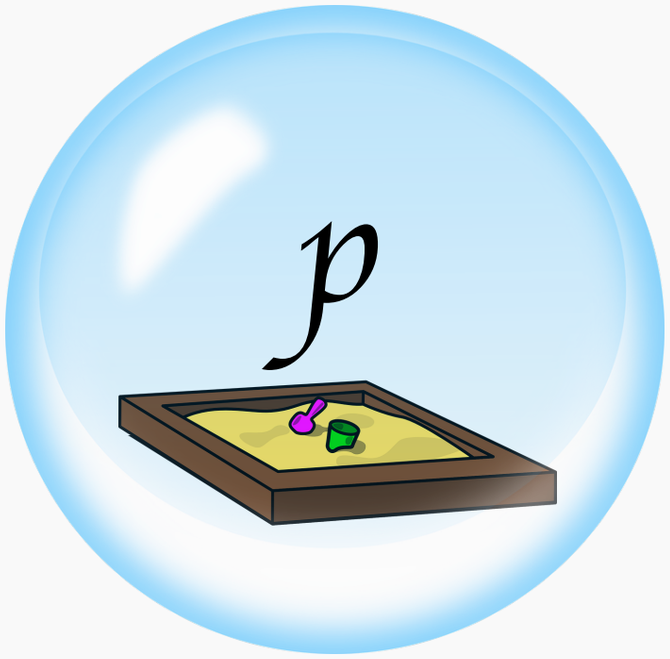

: (Inputs , OS Version) → Outputs

Reproducibility

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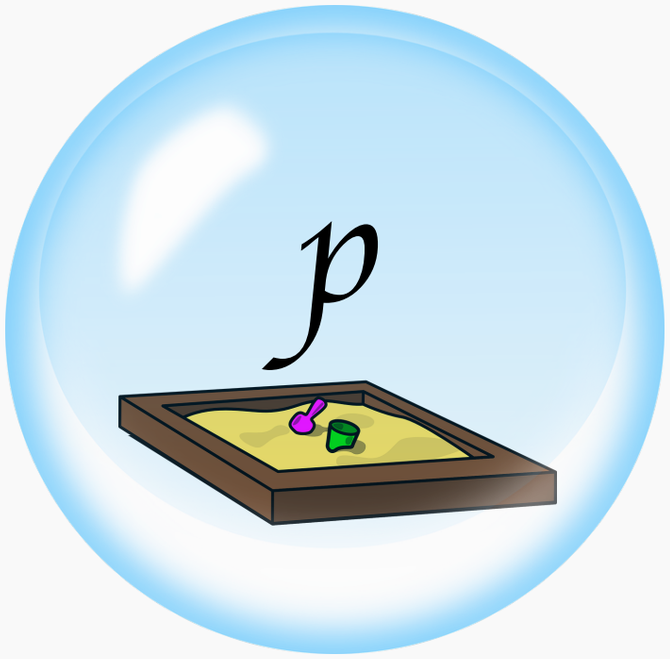
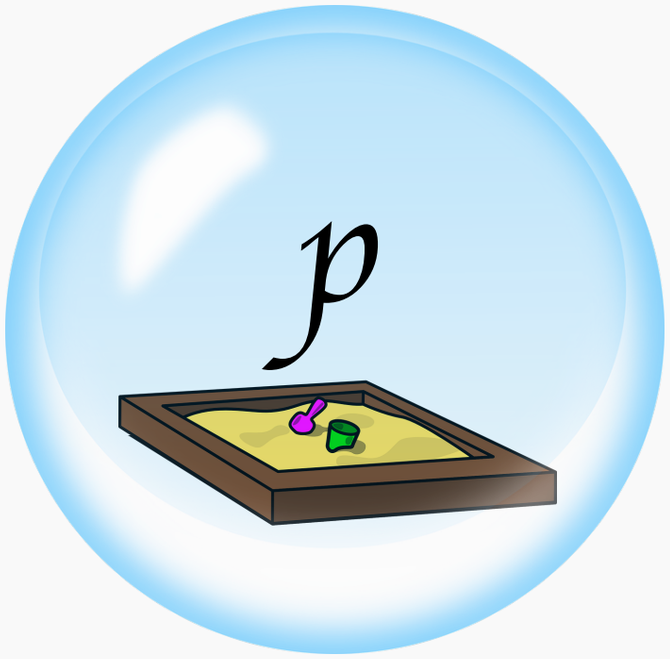


: (Inputs , Sched.Trace) → Outputs

Reproducibility

Portability



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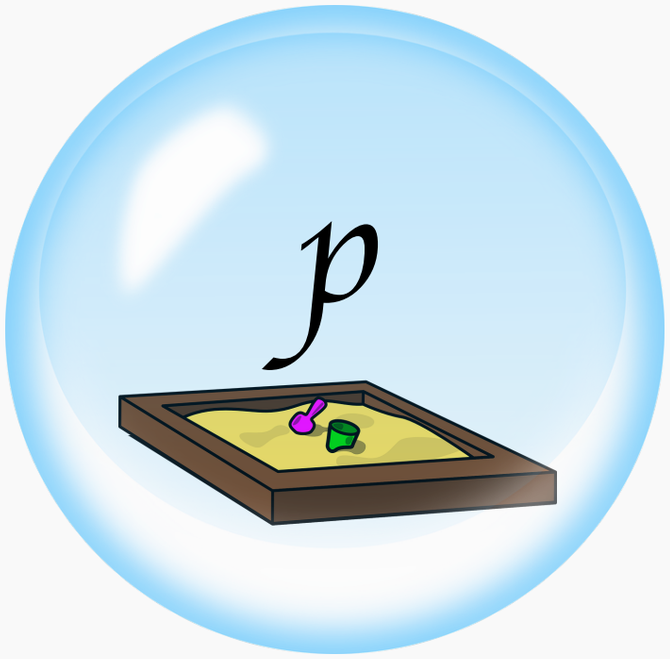
rr

mozilla

Reproducibility

Portability



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Reproducibility

Portability

- Still open problems for dynamic determinism enforcment: **user-space process tree determinism, file systems**

?

Reproducibility

Portability

Static ? checking

Reproducibility

Portability

Tony Hoare, 1971, on the prospect of **Static checking**

5

TOWARDS A THEORY OF PARALLEL PROGRAMMING

C. A. R. HOARE

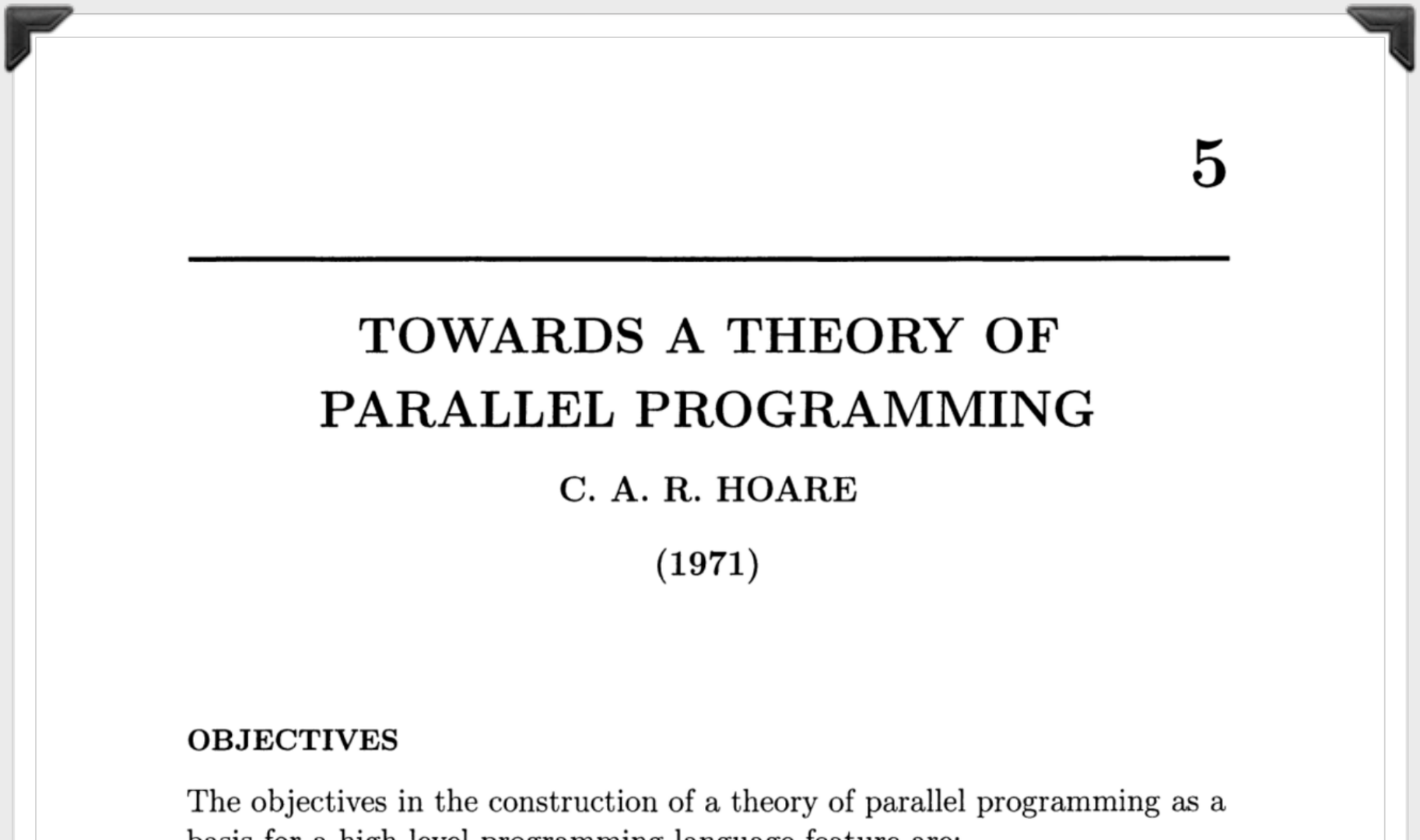
(1971)

OBJECTIVES

The objectives in the construction of a theory of parallel programming as a

Tony Hoare, 1971, on the prospect of **Static checking**

"It is therefore very important that a high-level language designed for [parallel programming] should provide complete security against time-dependent errors by means of a ***compile-time check****."*



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Determinism as a Safety property

```
{-# LANGUAGE Safe #-}
import Control.LVish
x = <your untrusted code>
main :: IO ()
main = print x
```

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…
main :: Det ()
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```

Relationship to program generation

- Archiving programs in source form requires precise representations of the:
  - code
  - compiler
  - environment
- (A “perfect name” or hash for a program.)

2. Composable Autotuning

- Typically:
  - Global parameters
  - Hacky Scripts
  - Fixed K-dimensional search spaces

```
$ cat “1,2,3” > params.txt
$ ./run_stuff.sh
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2. Composable Autotuning

- Typically:
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$ cat “1,2,3” > params.txt
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```

Ideal

```
import A (a)
import B (b)
…
   do  a  — may use auto-tuning
       b  — may use auto-tuning
       …
```

One idea

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- Use an Applicative transformer (Tune m a)

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Avoid:

```
x = runSearch $
    setParam (Proxy::Proxy "a") (0,10) $
    setParam (Proxy::Proxy "b") (10,20) $
    go
```

Problems:

- *Persistence* is awkward
  - Store learned results
  - Comes back to naming programs:
    - What is the *same* program?
  - And naming *choices*:
    - choice structure is a (un)labeled tree?

3. Fusion for nested, irregular data

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```
fold1(setUnion,
      map(nbrs,states))
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fold1(setUnion,
      map(nbrs,states))
```

```
do acc ← newEmptySet()
   forEach x ∈ states:
     forEach n ∈ nbrs(x):
       insert(n,acc)
```

4. Data structure representation rewrites

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Set (Maybe a) ⇒ (Bool, Set a)
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Set (Maybe a) ⇒ (Bool, Set a)
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- (Closed type families are sufficient for this example.)

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- Should I need to know whether a particular expression happens at a particular stage?
- Staging *goals*
  - this function isn't called at runtime (INLINE)
  - this datatype doesn't appear at runtime
  - this type class creates no dictionaries at runtime

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- *(WIP: w/ Ranjit Jhala)*