Auto-Mobiles

Optimising Message-Passing Concurrency

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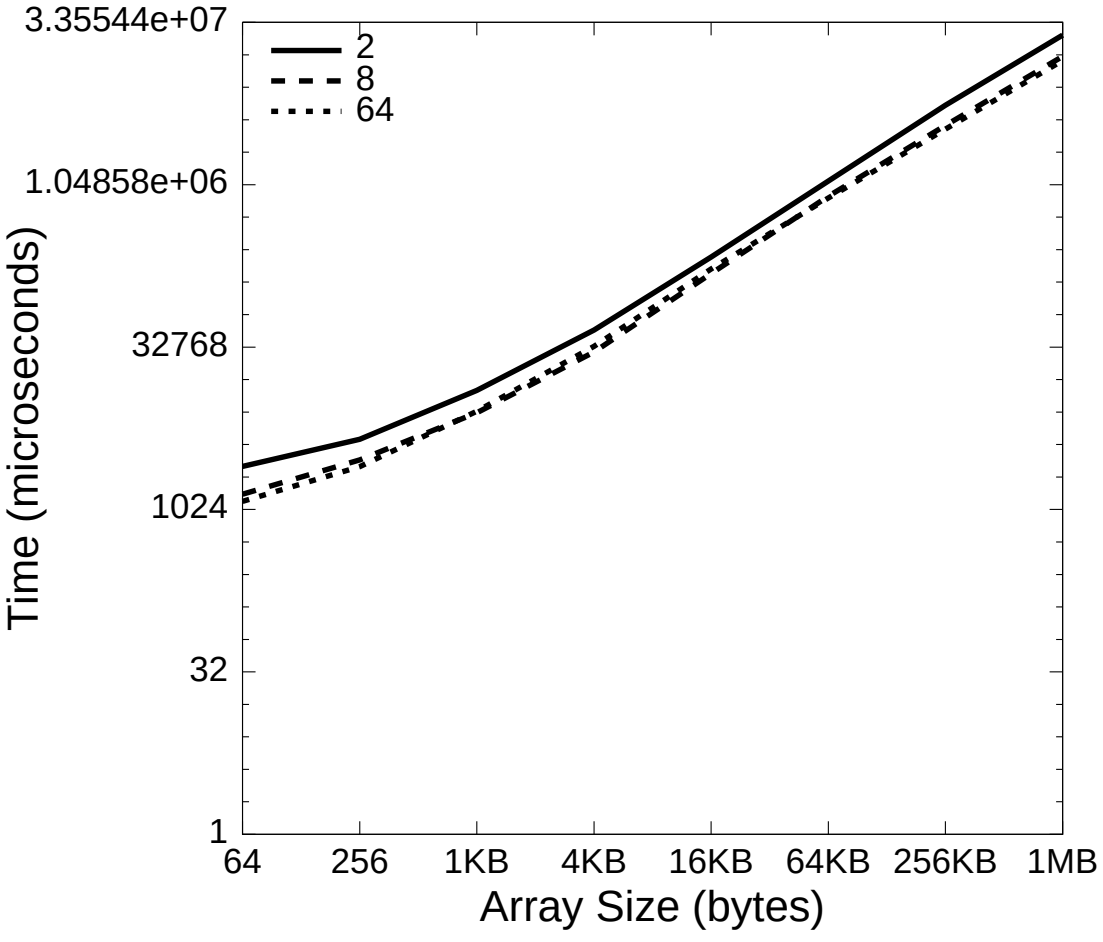
Auto-Mobiles

- Compiler Optimisation
  - For message-passing languages like occam 2
  - Increases speed
  - Reduces memory use
- No change to your code required

Best Case



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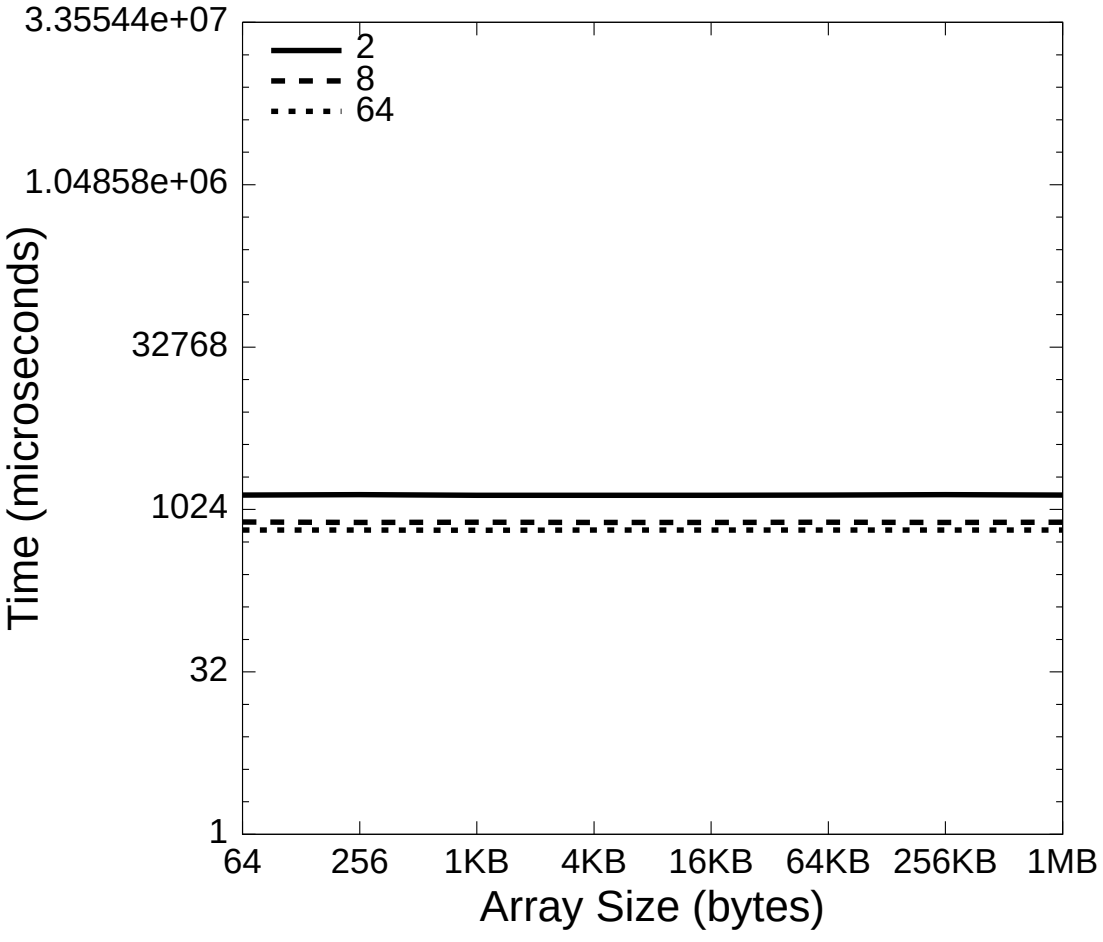

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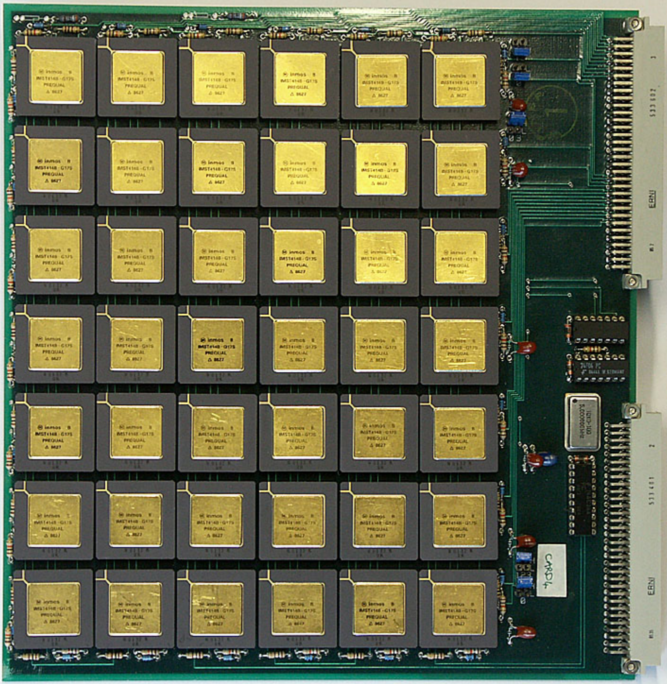
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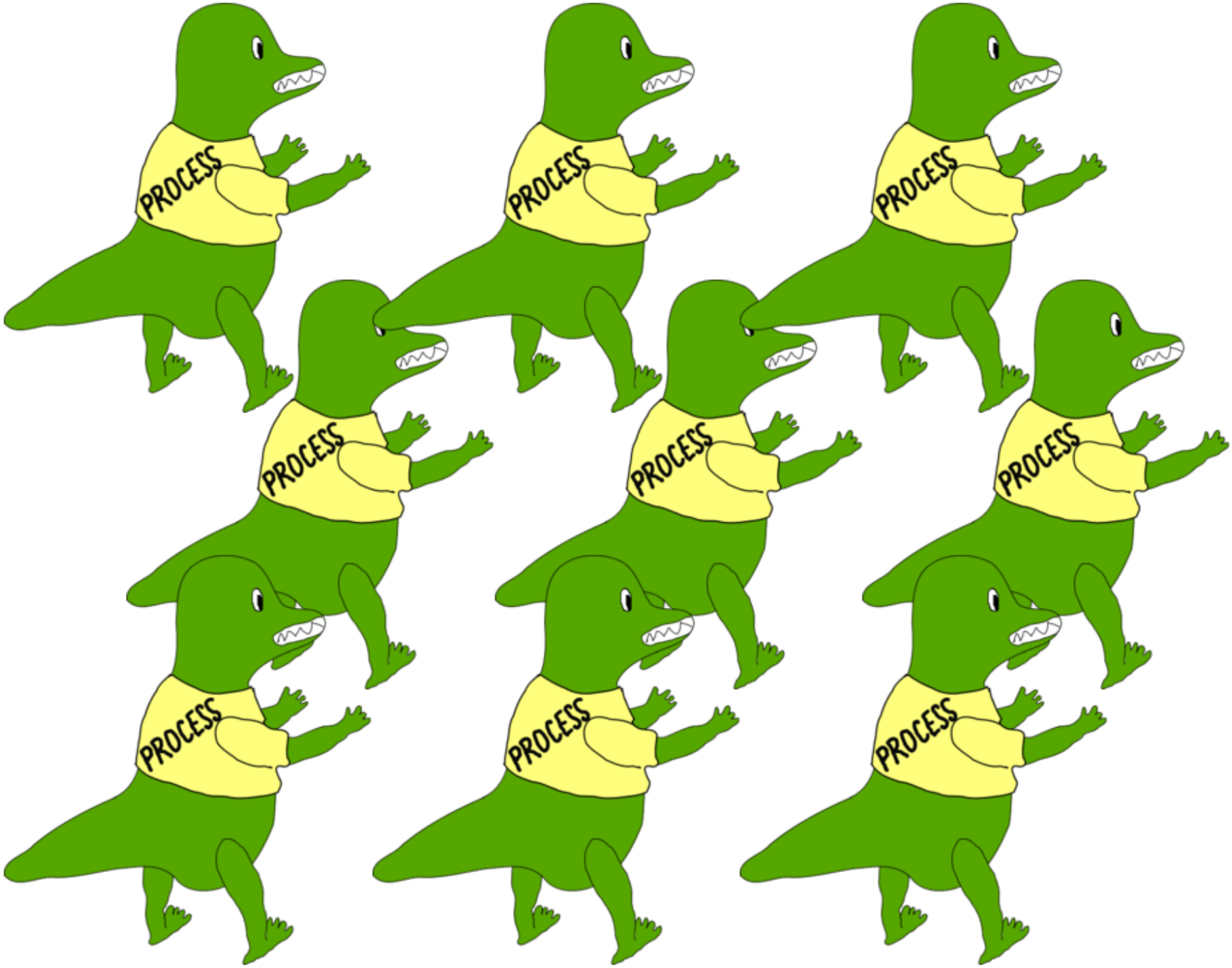
PREQUAL
ERNI


PROCESS
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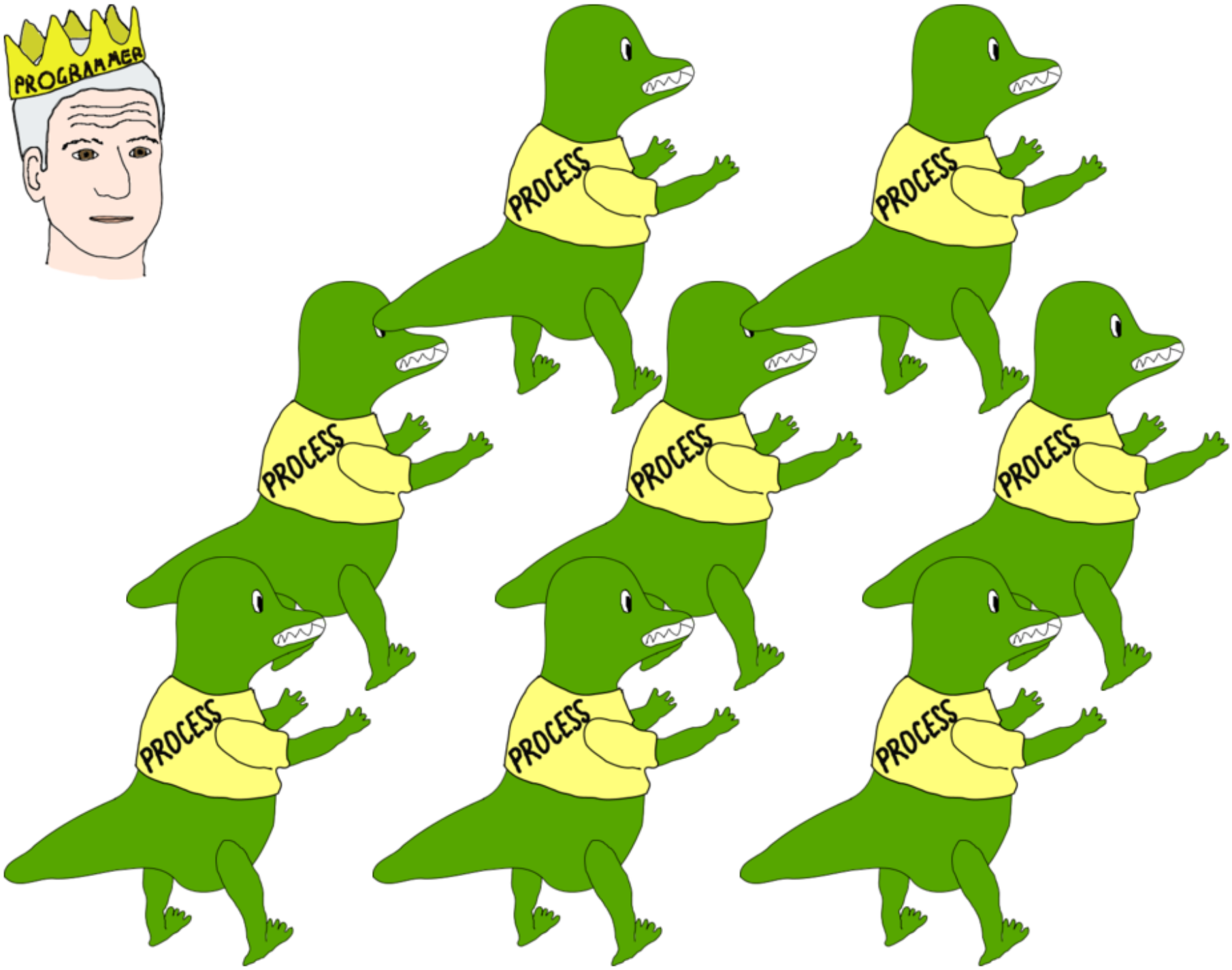
PROGRAMMER
PROCESS
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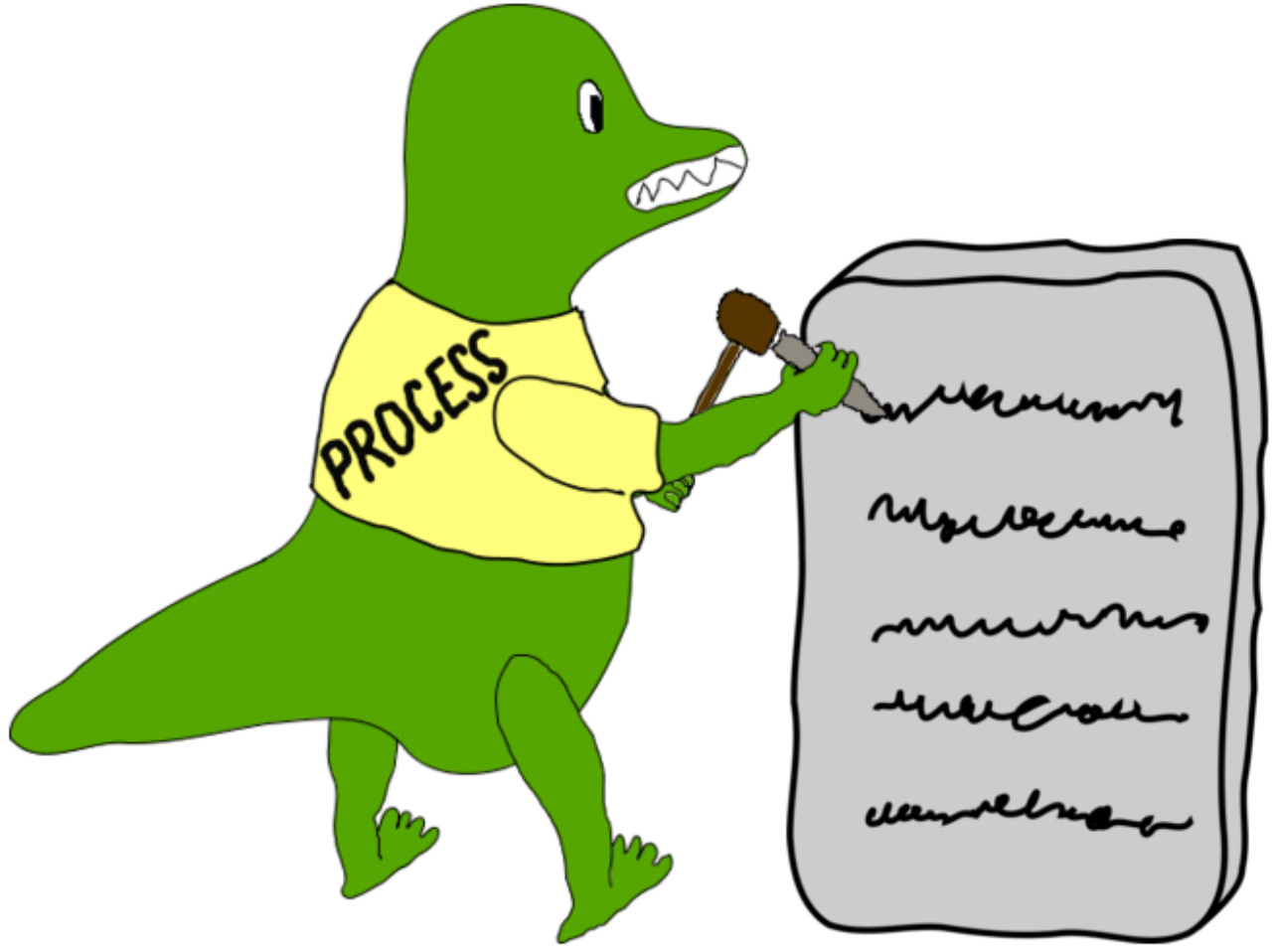
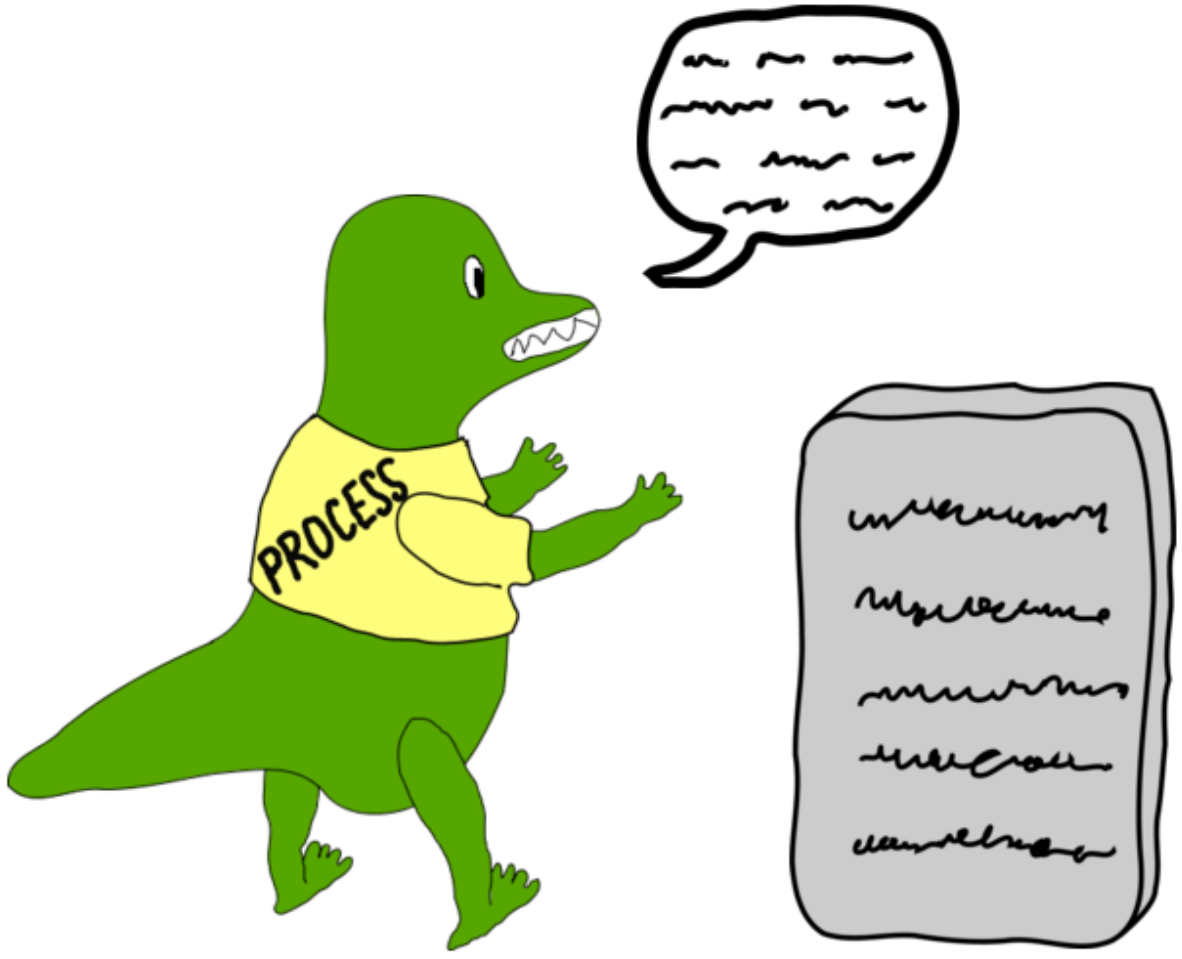
PROCESS

Data Operations

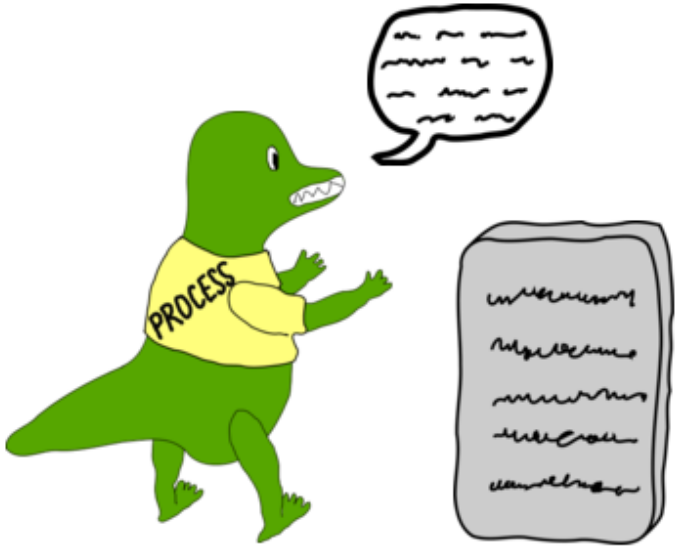
Write



Read



Communication



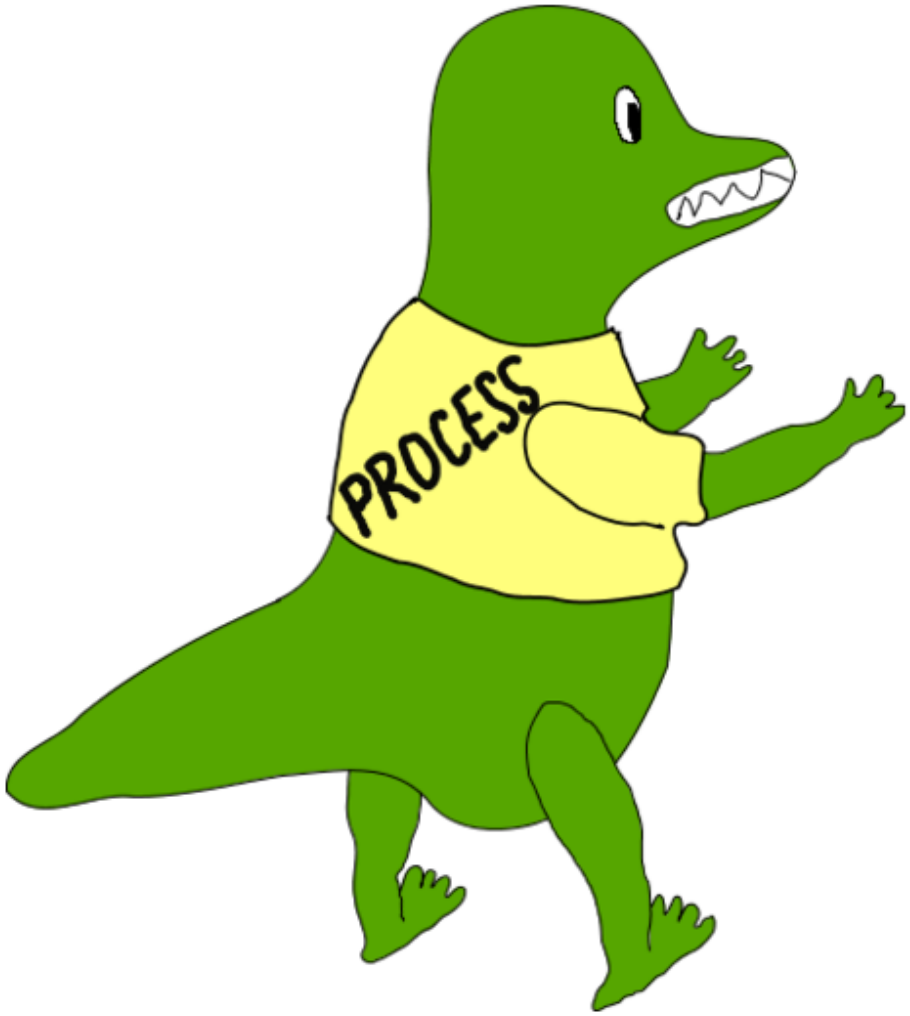
Reading

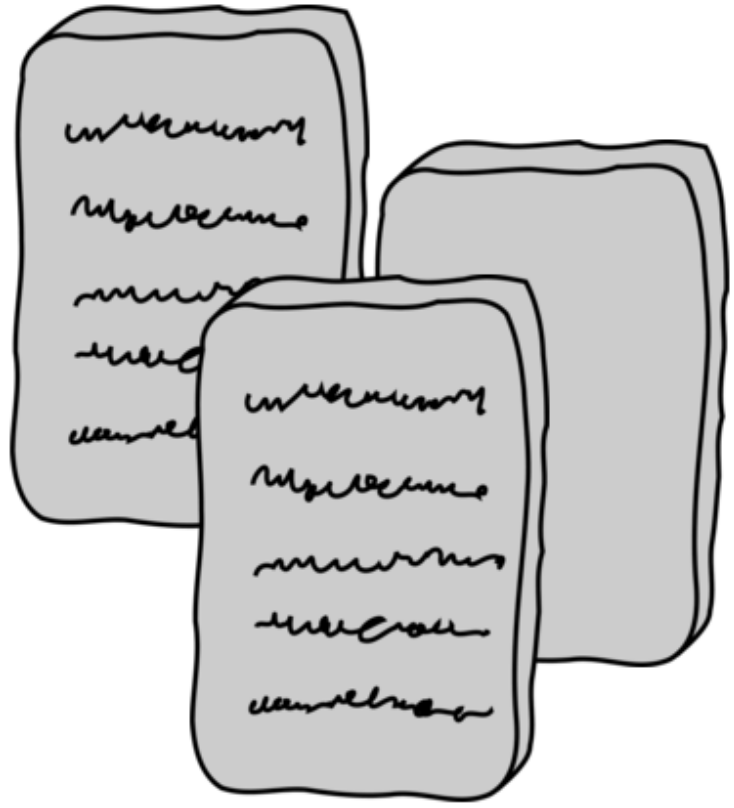
Writing

Communication

Problems with occam 2

Statically Sized Storage





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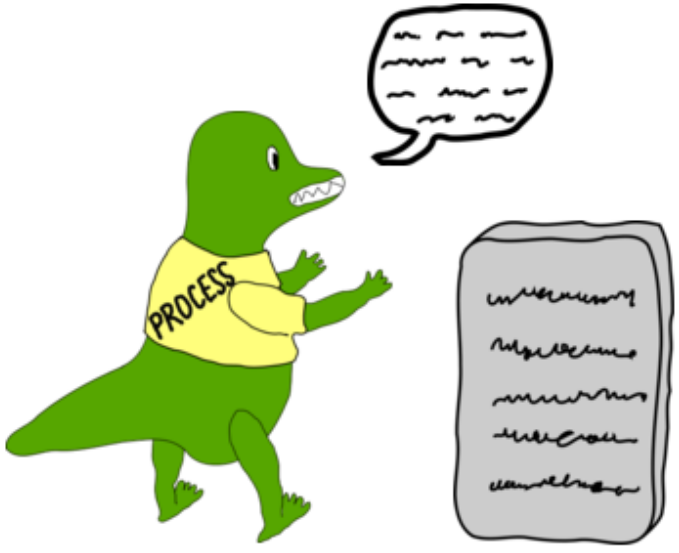

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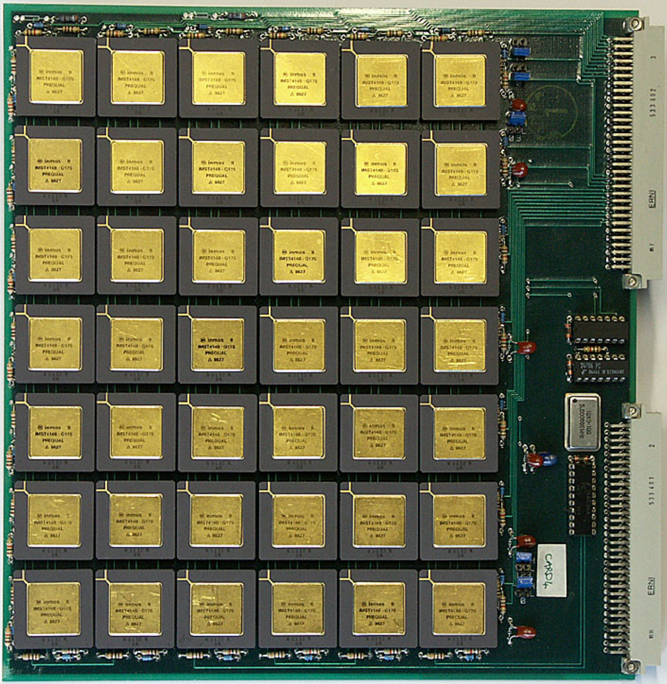
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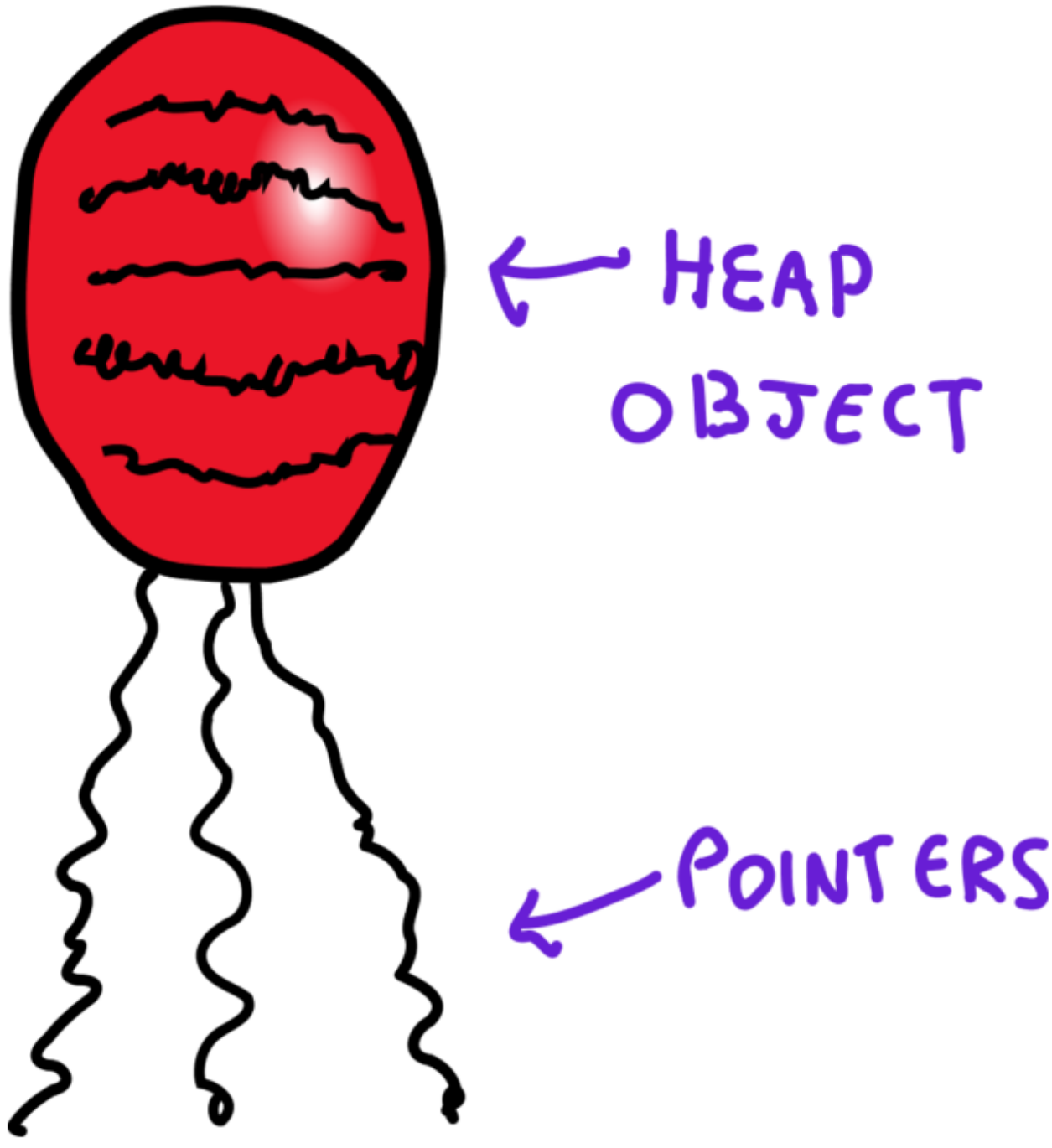
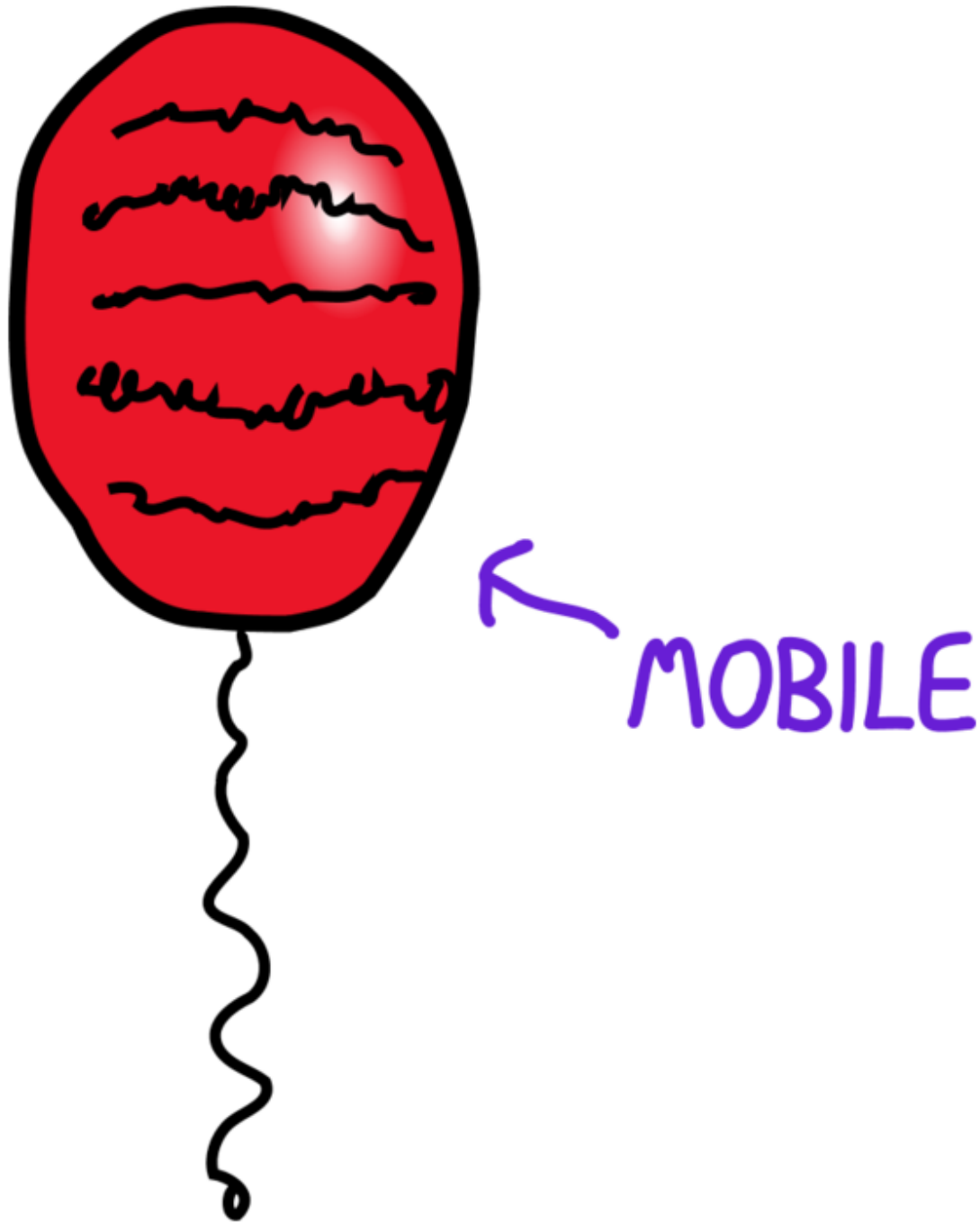
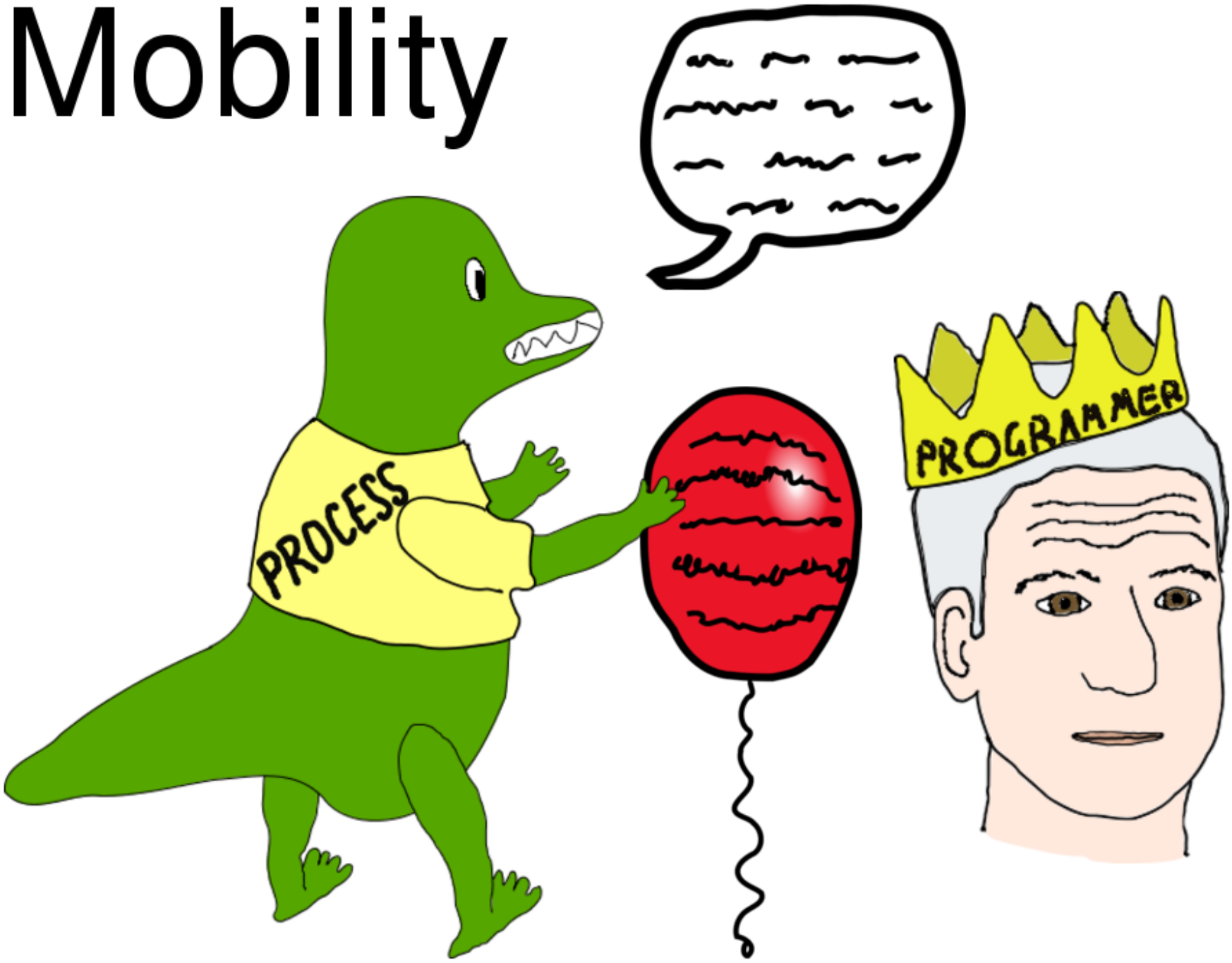
PREQUAL
8627
ERNI
CARD4

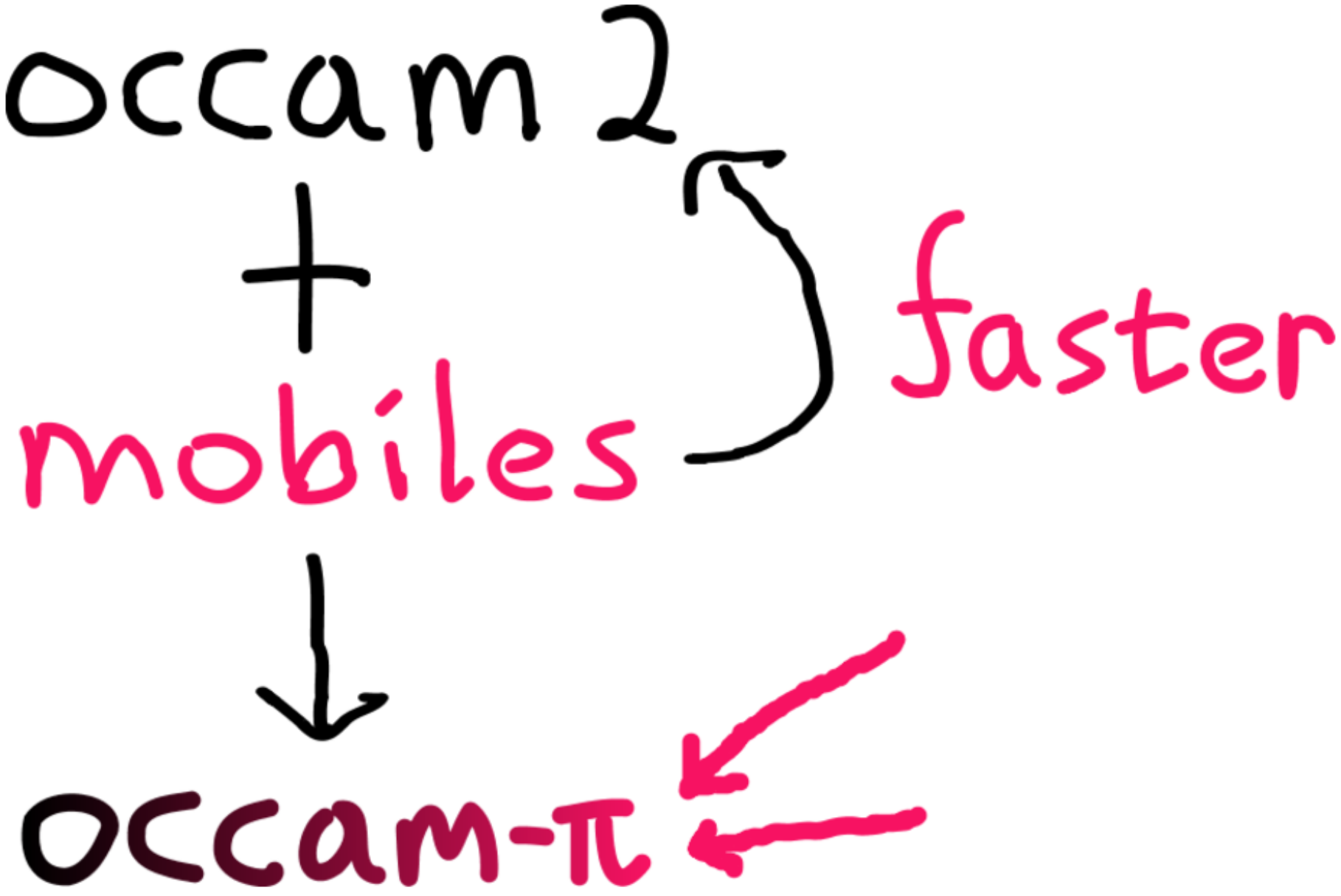

intel
Core™2 Duo
intel

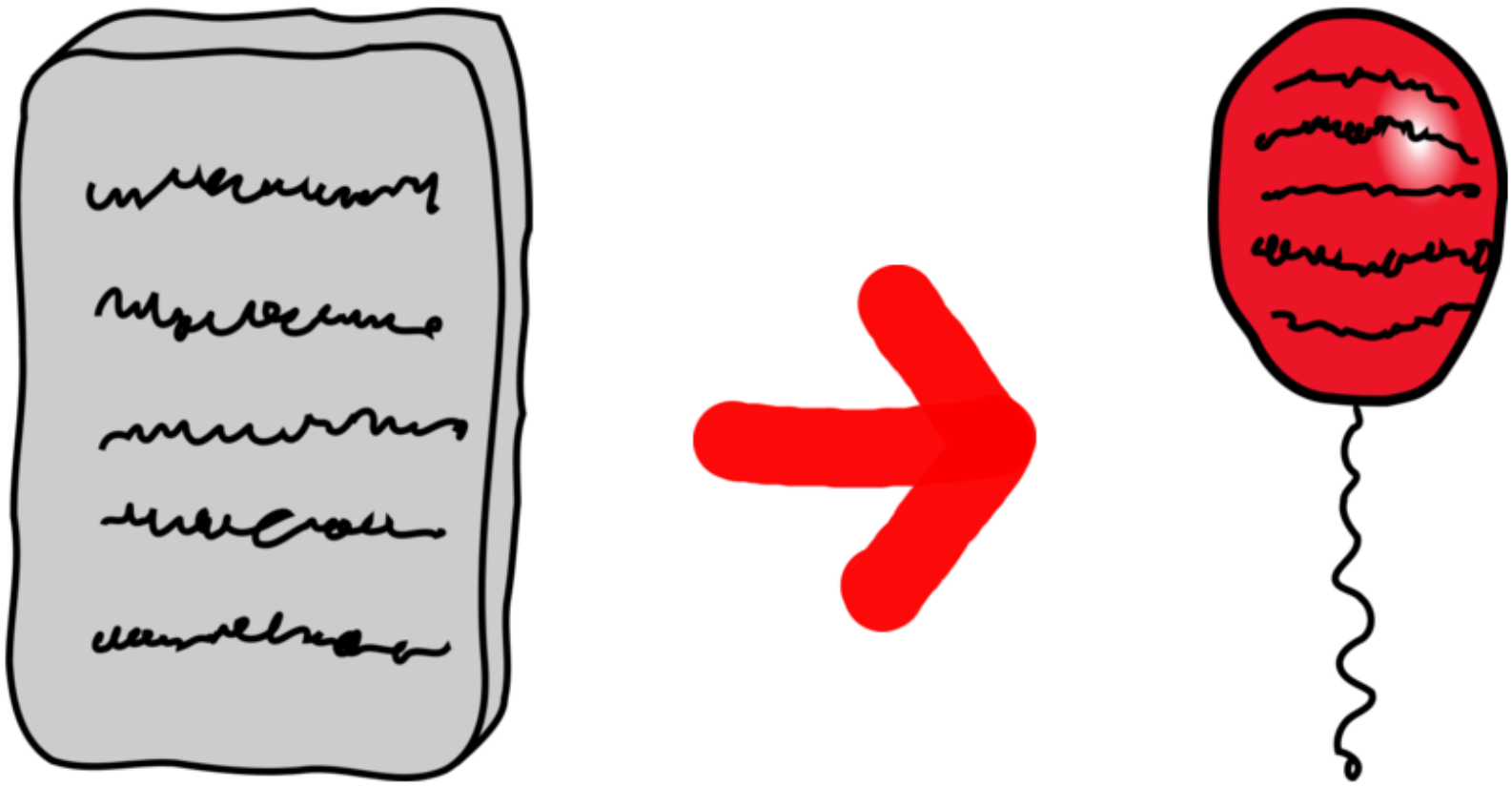

HEAP OBJECT
POINTERS


MOBILE

Mobility




occam 2
+
mobiles
faster
occam-π



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Communication

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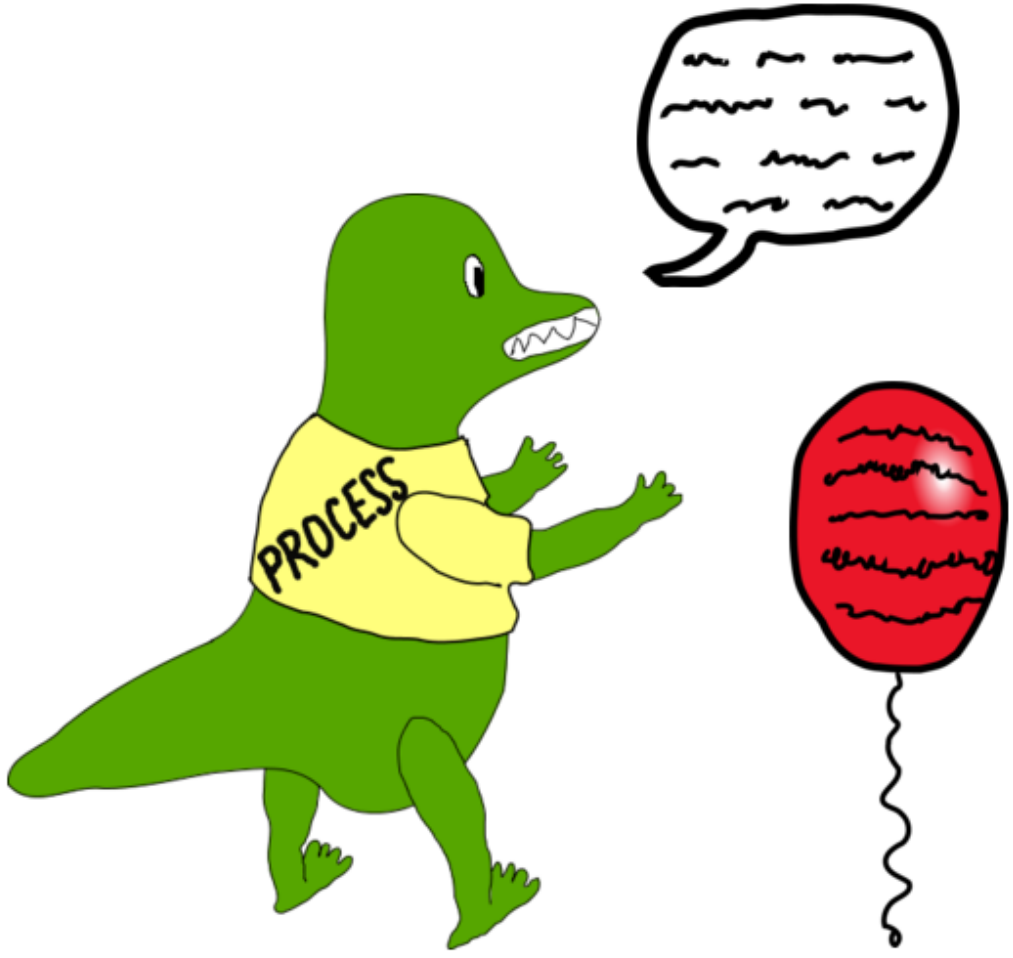

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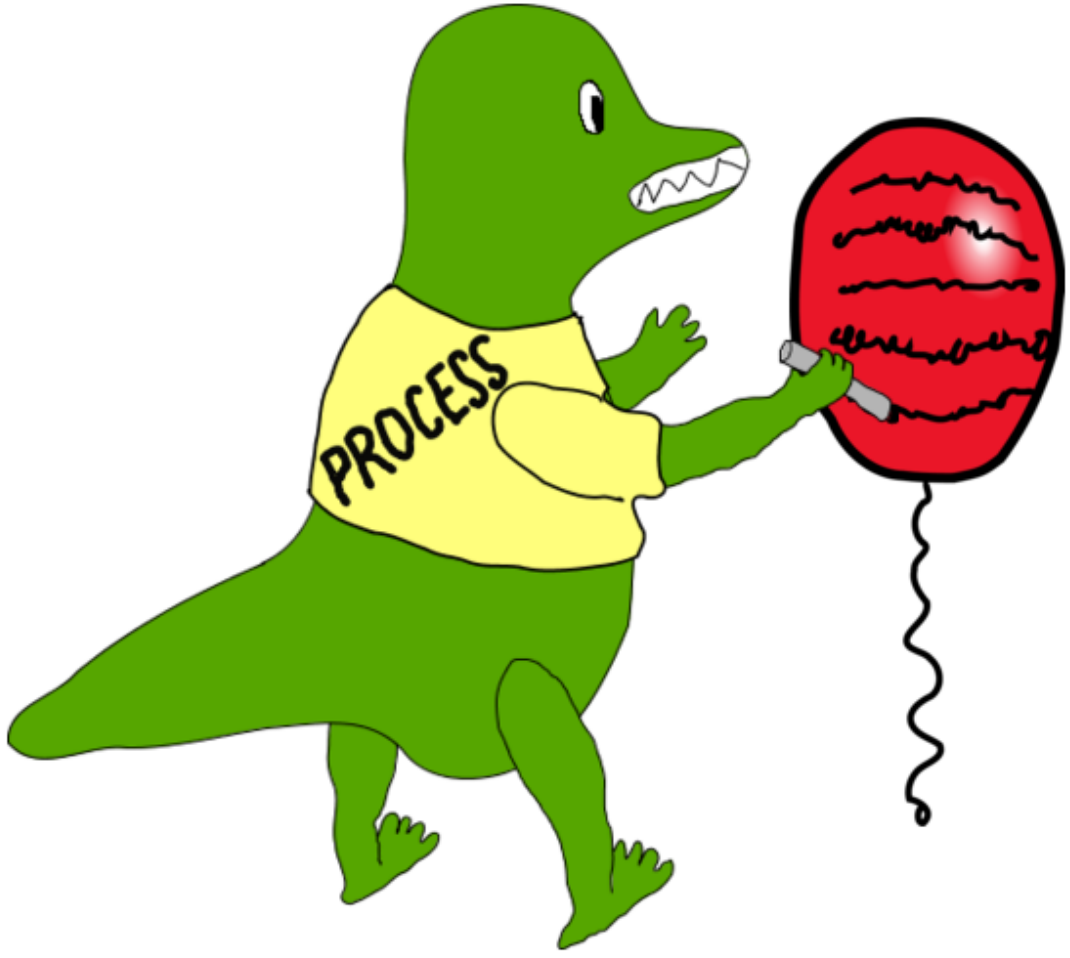
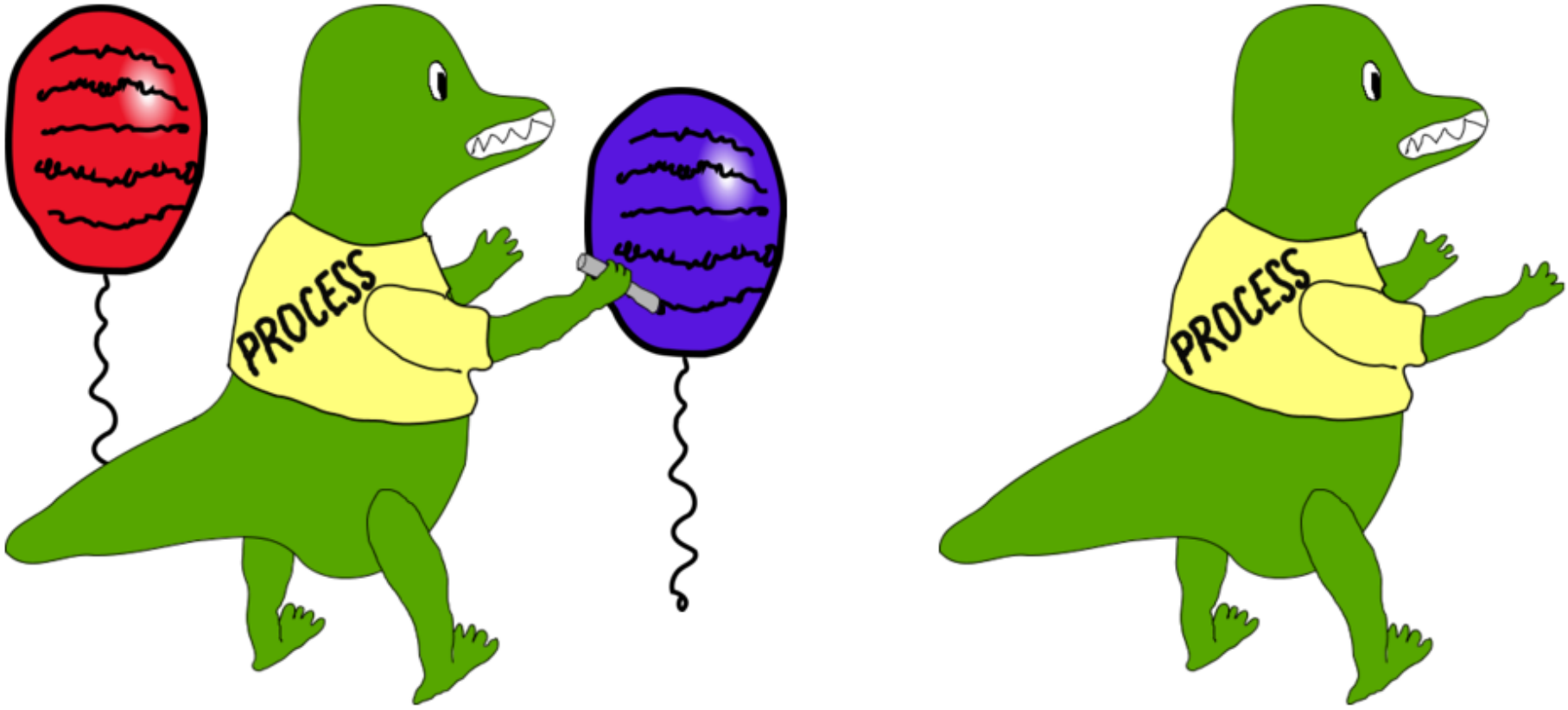


Communication



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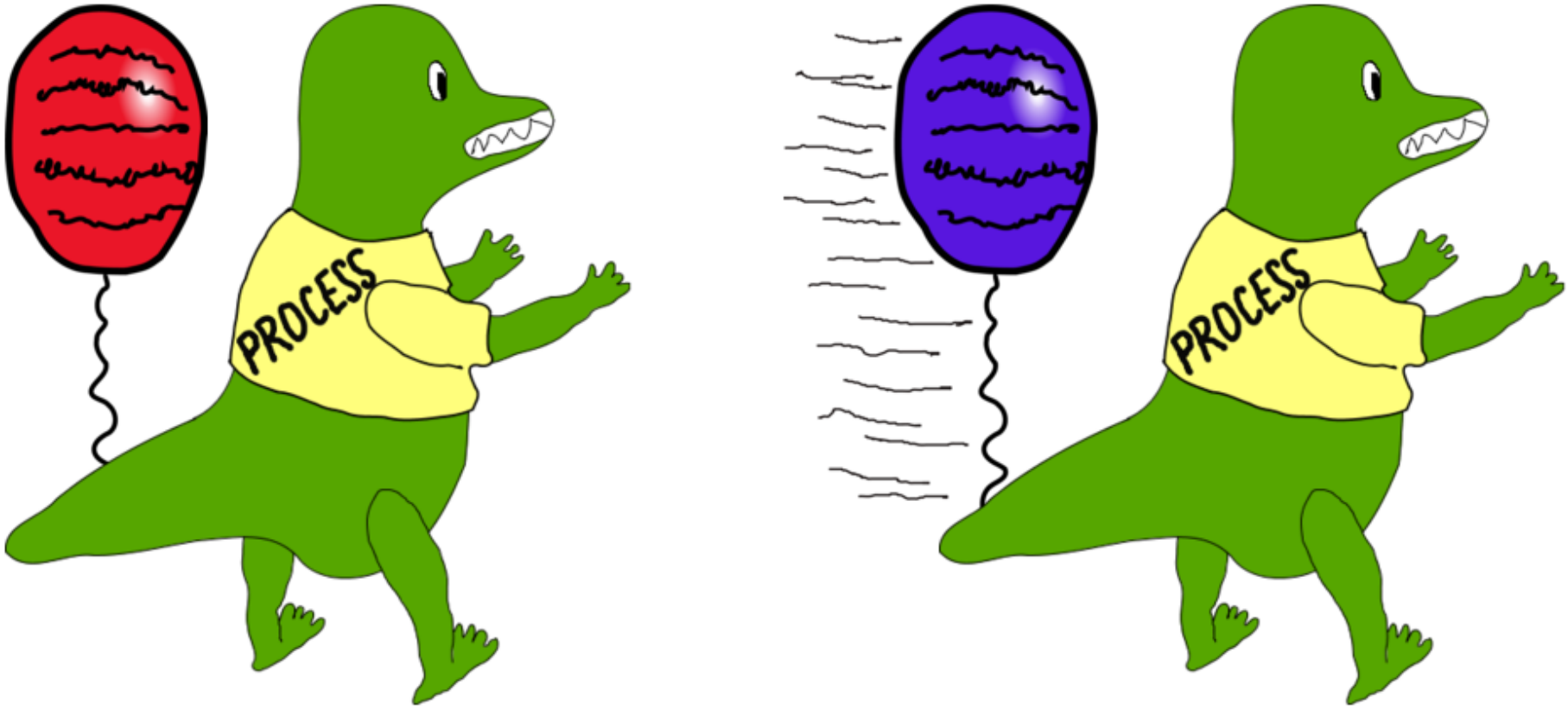

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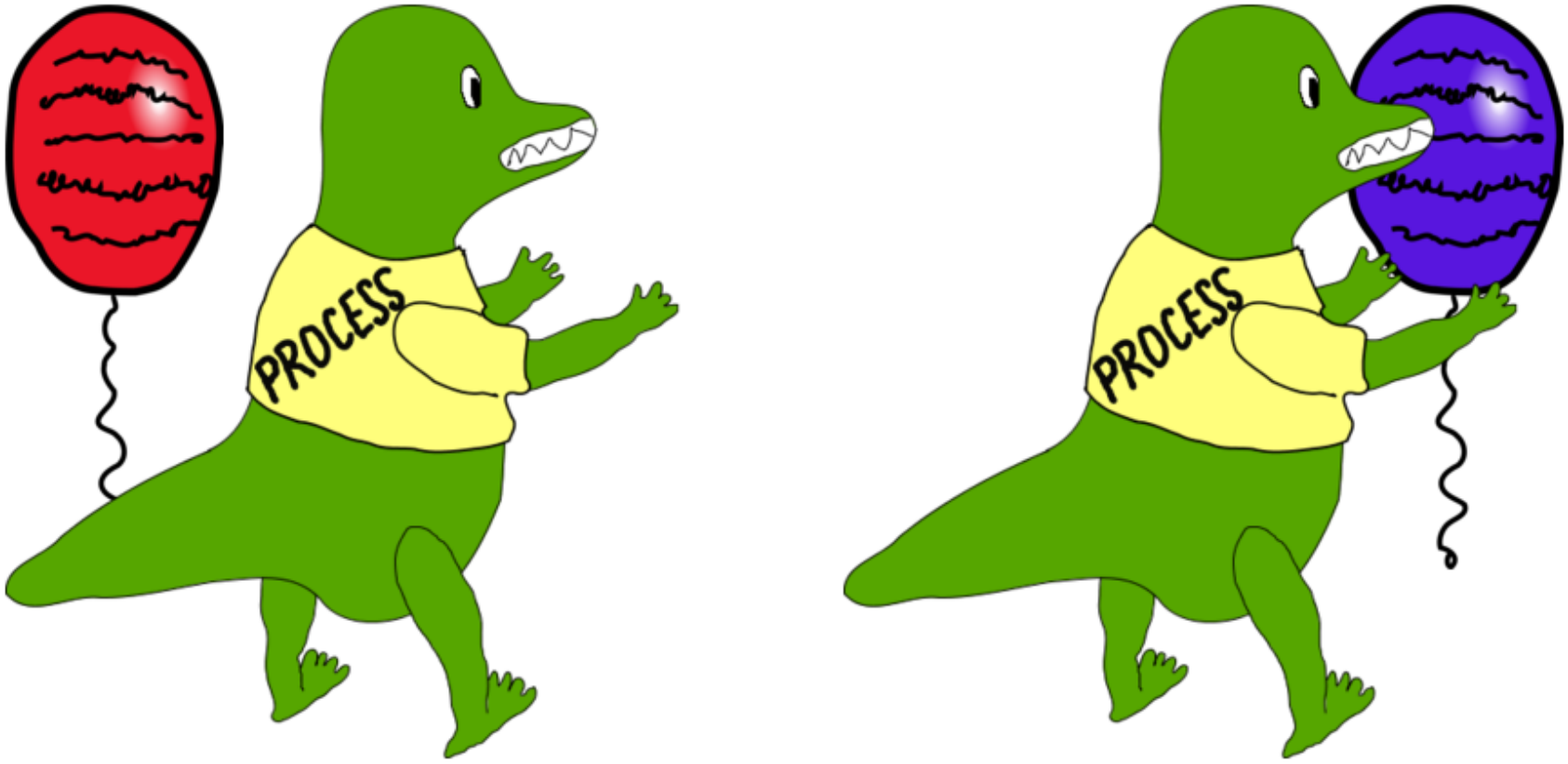
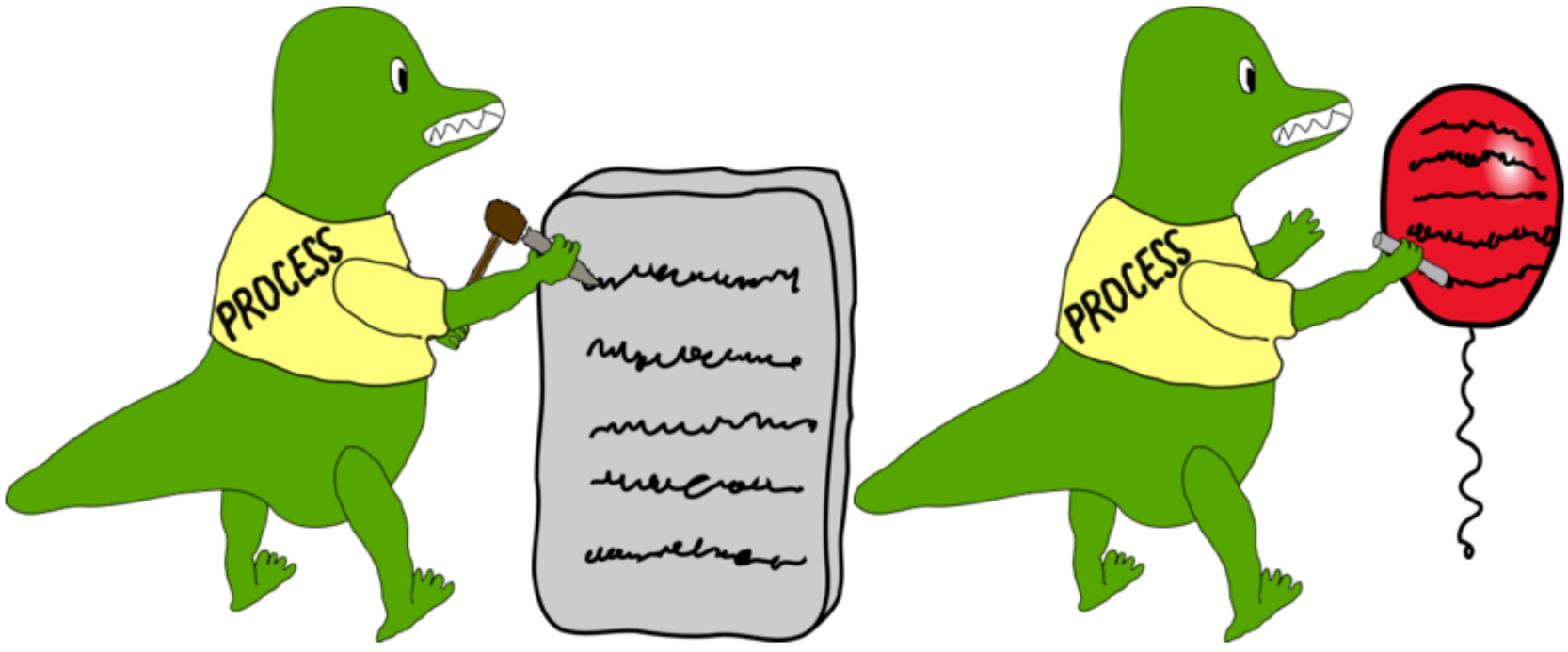


Nothing Gained (Yet)



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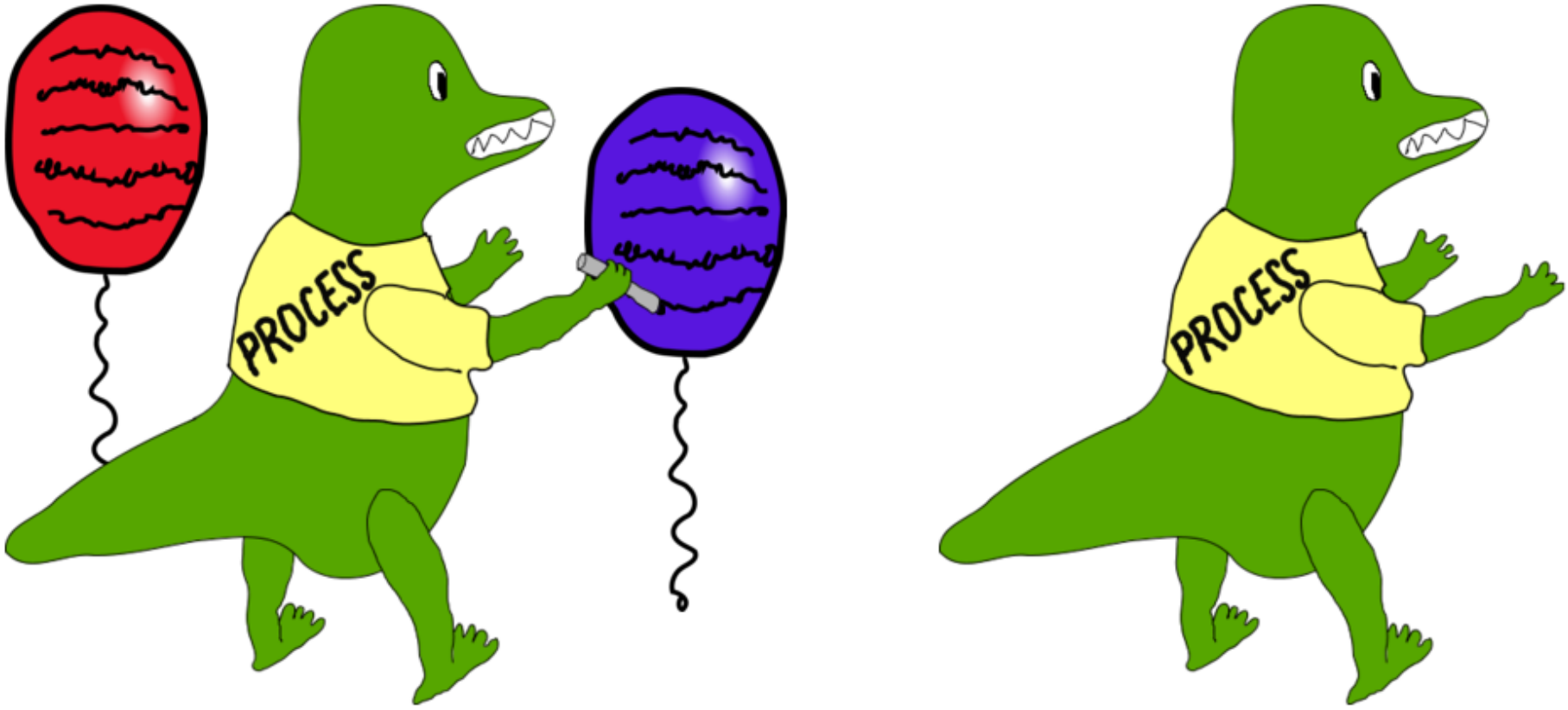

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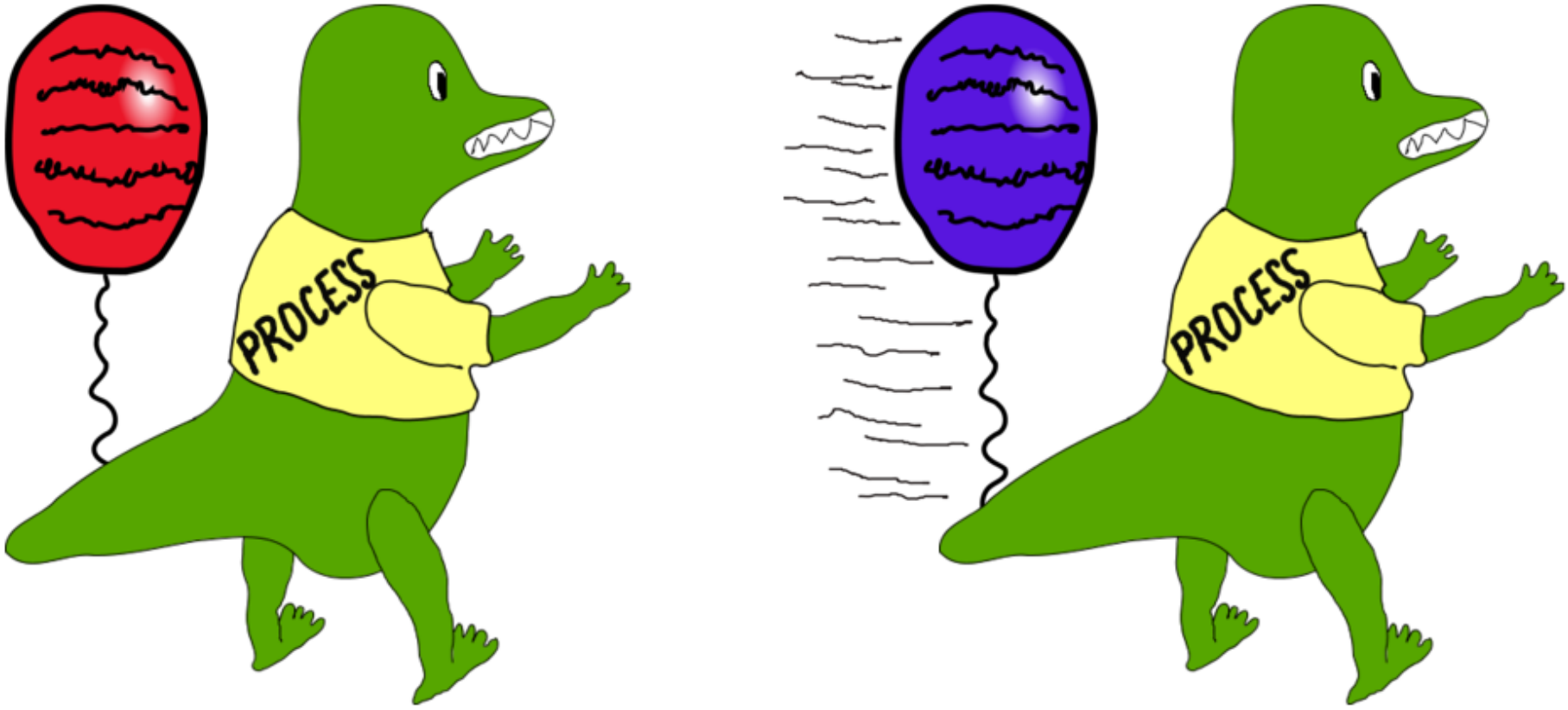

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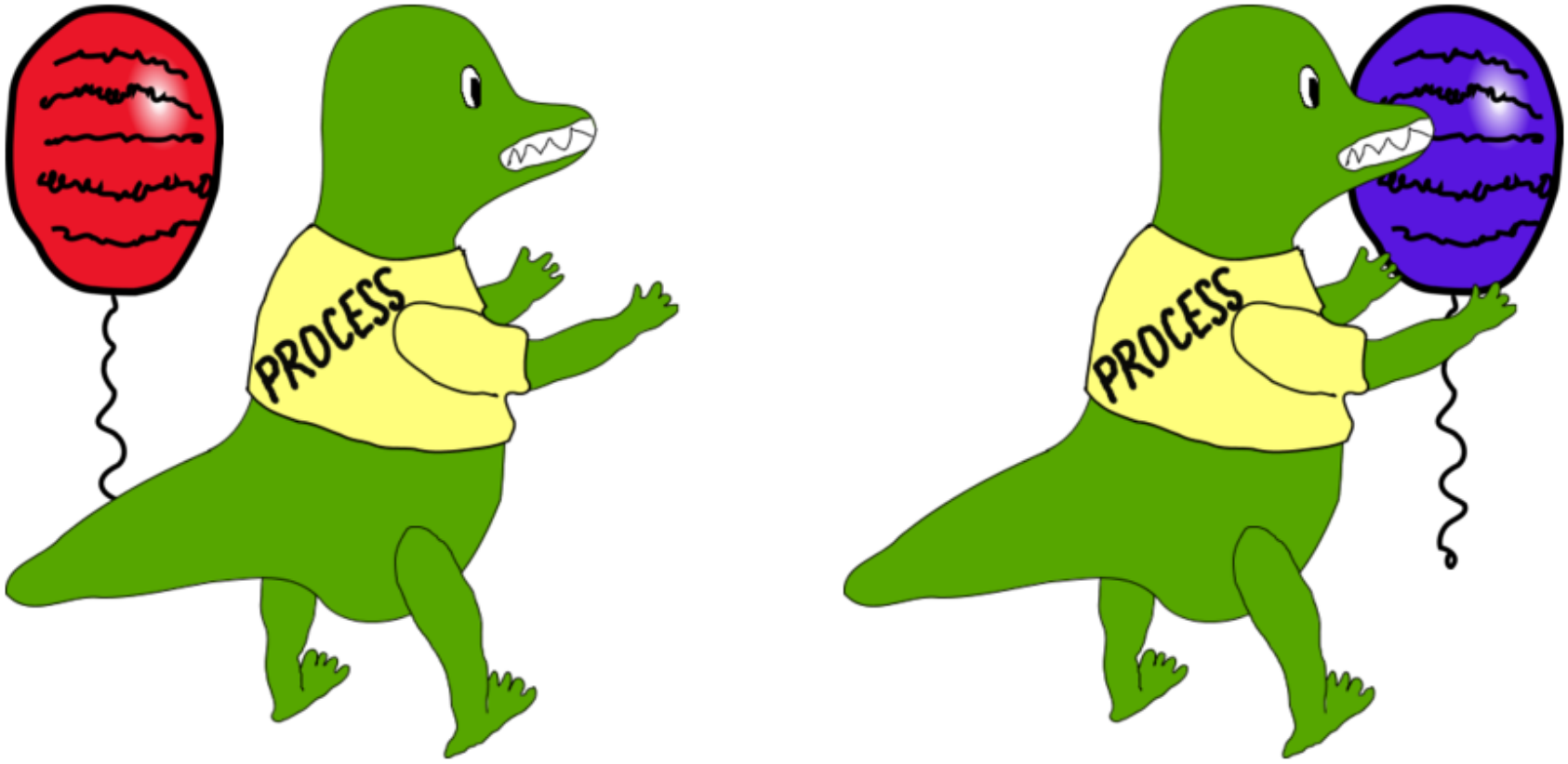

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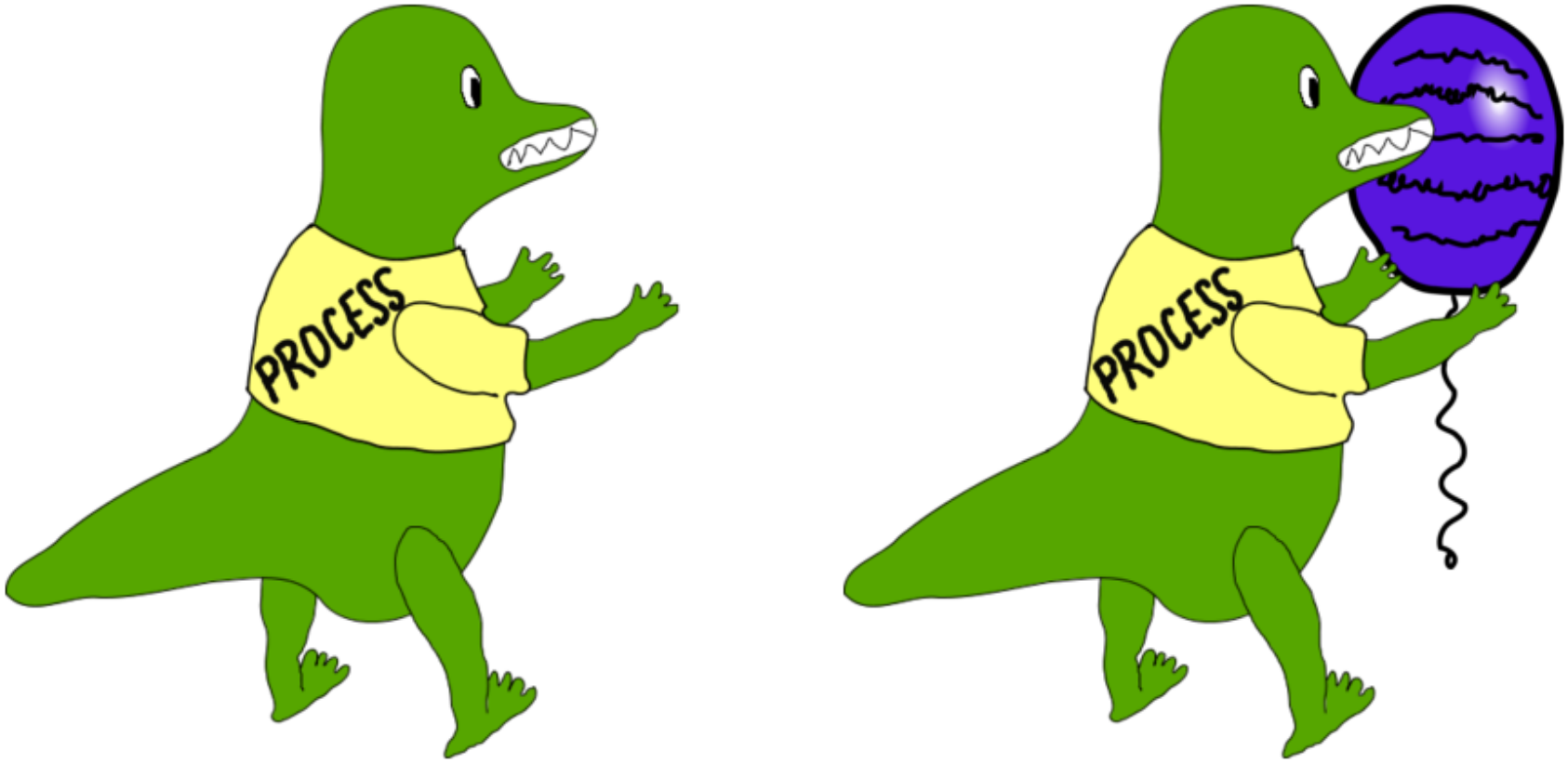

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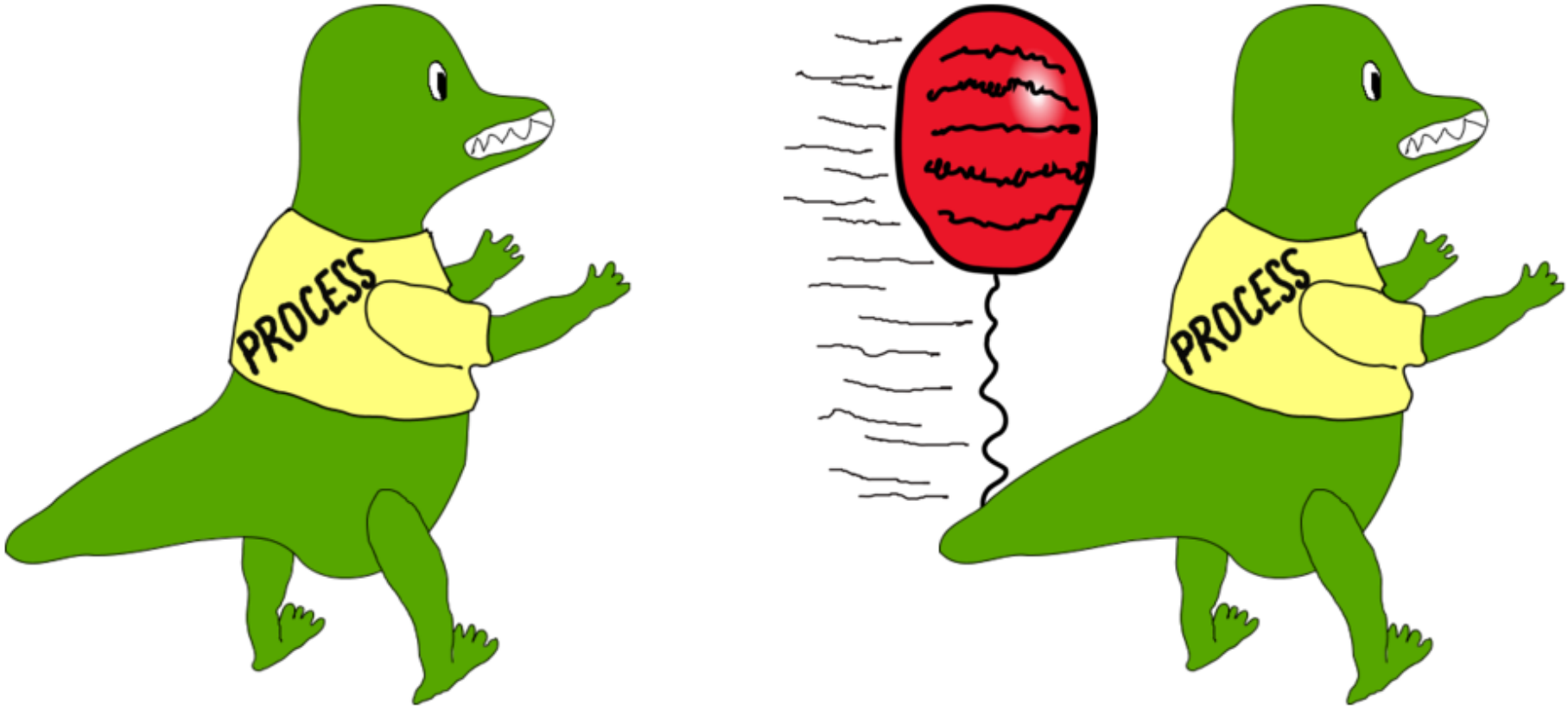

Idea behind Auto-Mobiles

- Make all non-tiny data mobile (i.e. a heap object)
- Normally, copy and send reference
- If you don't need your copy afterwards, send your original
- The recipient doesn't need to know which you did!

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Compile-Time Program Flow Analysis

Flow Analysis Examples

```
PROC id (CHAN FOO in?, out!)
  FOO x:
  WHILE TRUE
    SEQ
      in ? x
      out ! x
:
```

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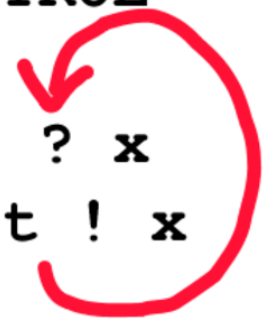

Flow Analysis Examples

```
PROC id.100 (CHAN FOO in?, out!)
  FOO x:
  SEQ i = 0 FOR 100
    SEQ
      in ? x
      out ! x
:
```

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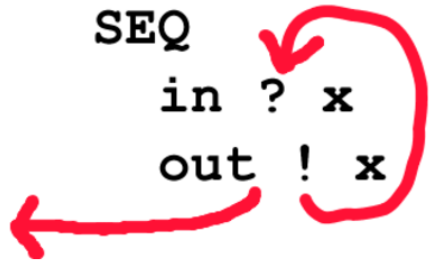
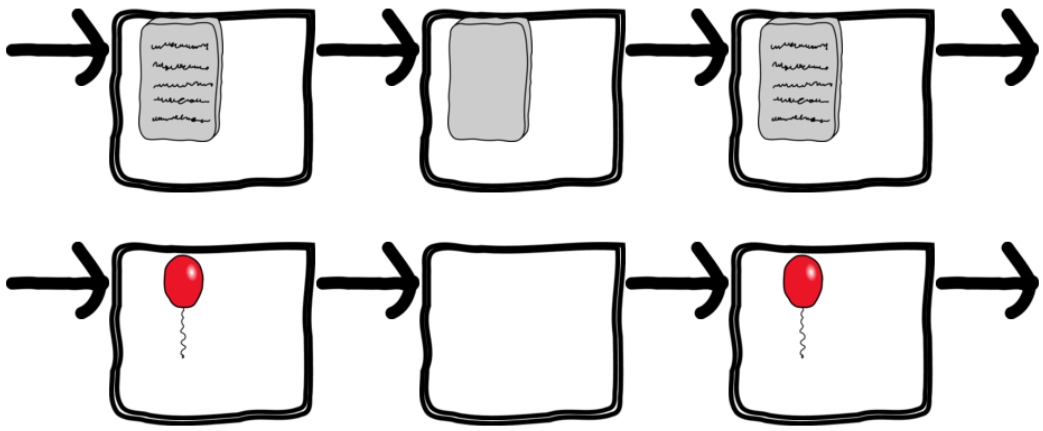


Memory Use



Speedup Bounds

Simplifying assumptions:

- All data same size
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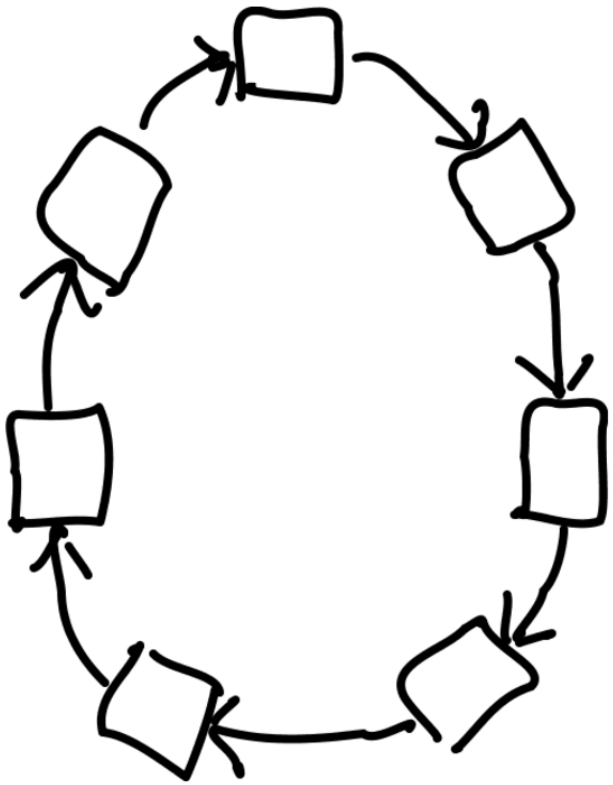
$$\text{Speedup Factor Bound} = \frac{1}{1-M}$$

Benchmark 1 of 3: The Ring



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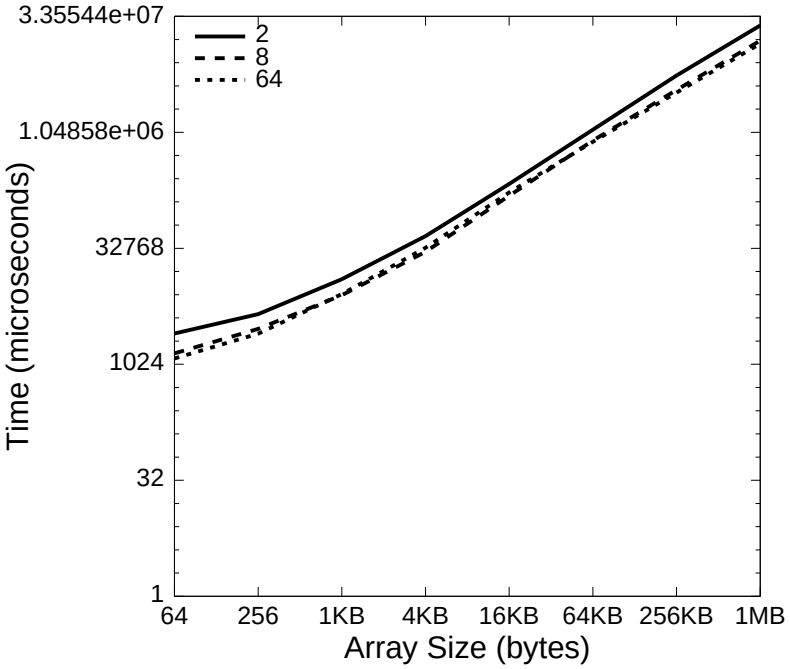

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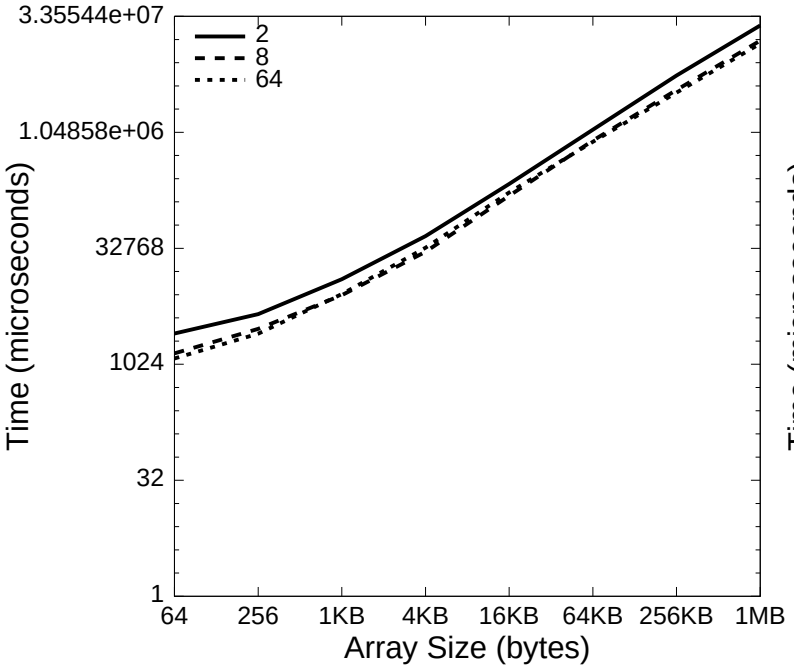

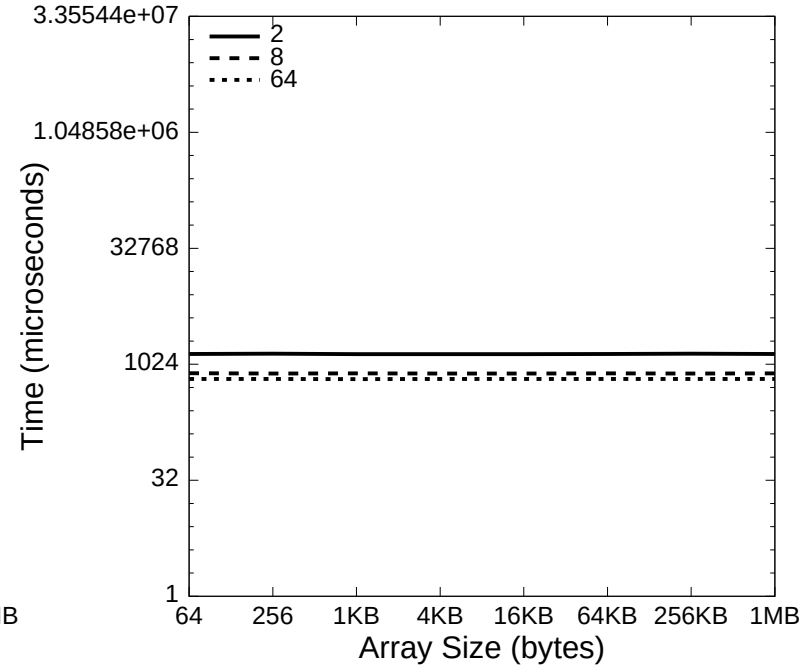

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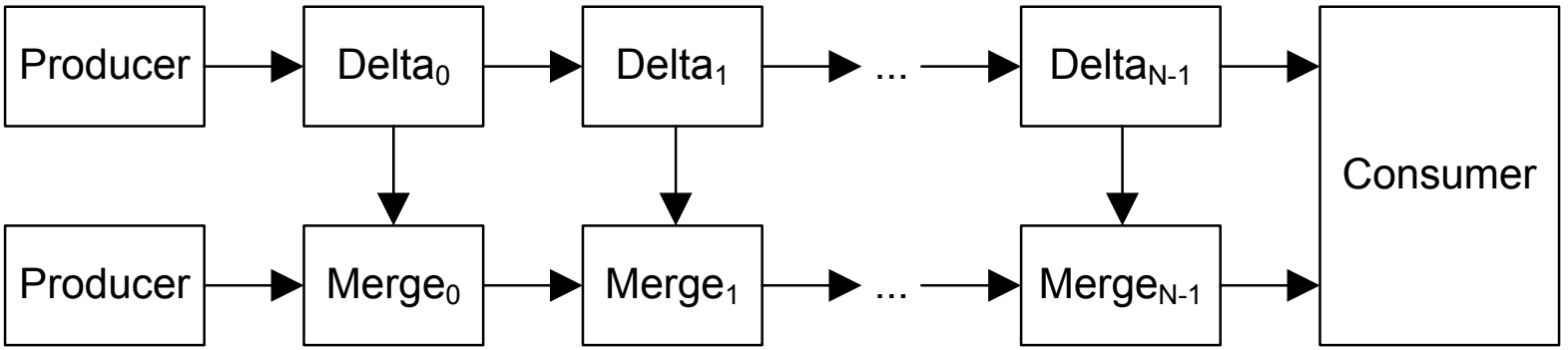
Benchmark 2 of 3: The Twin Pipeline



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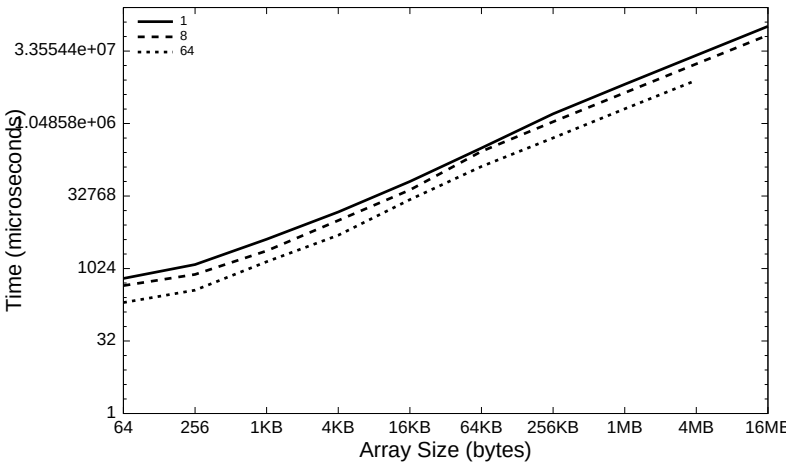

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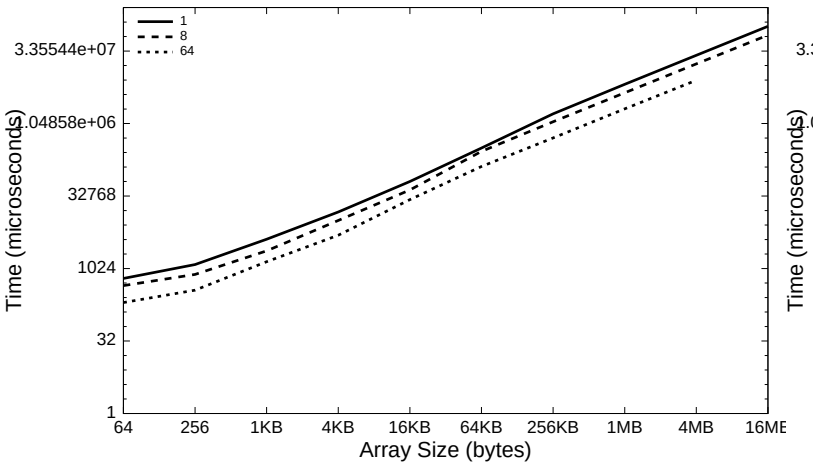

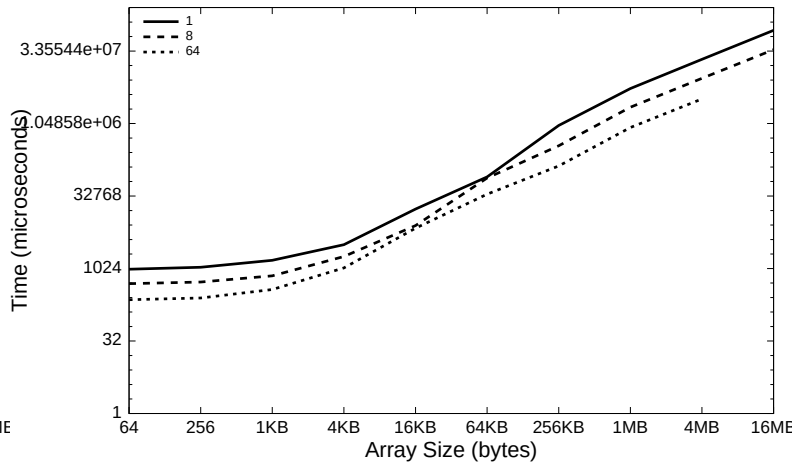

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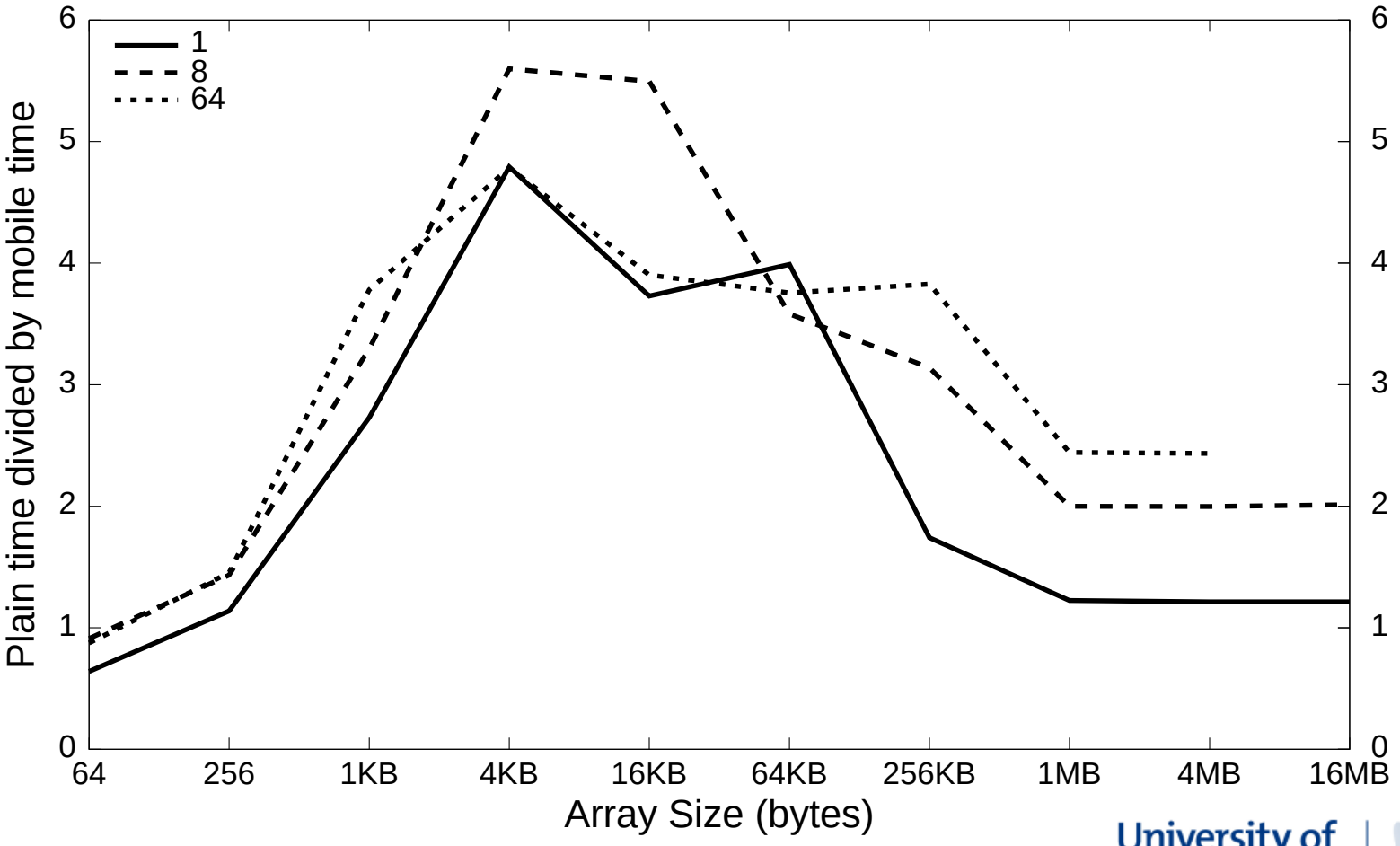

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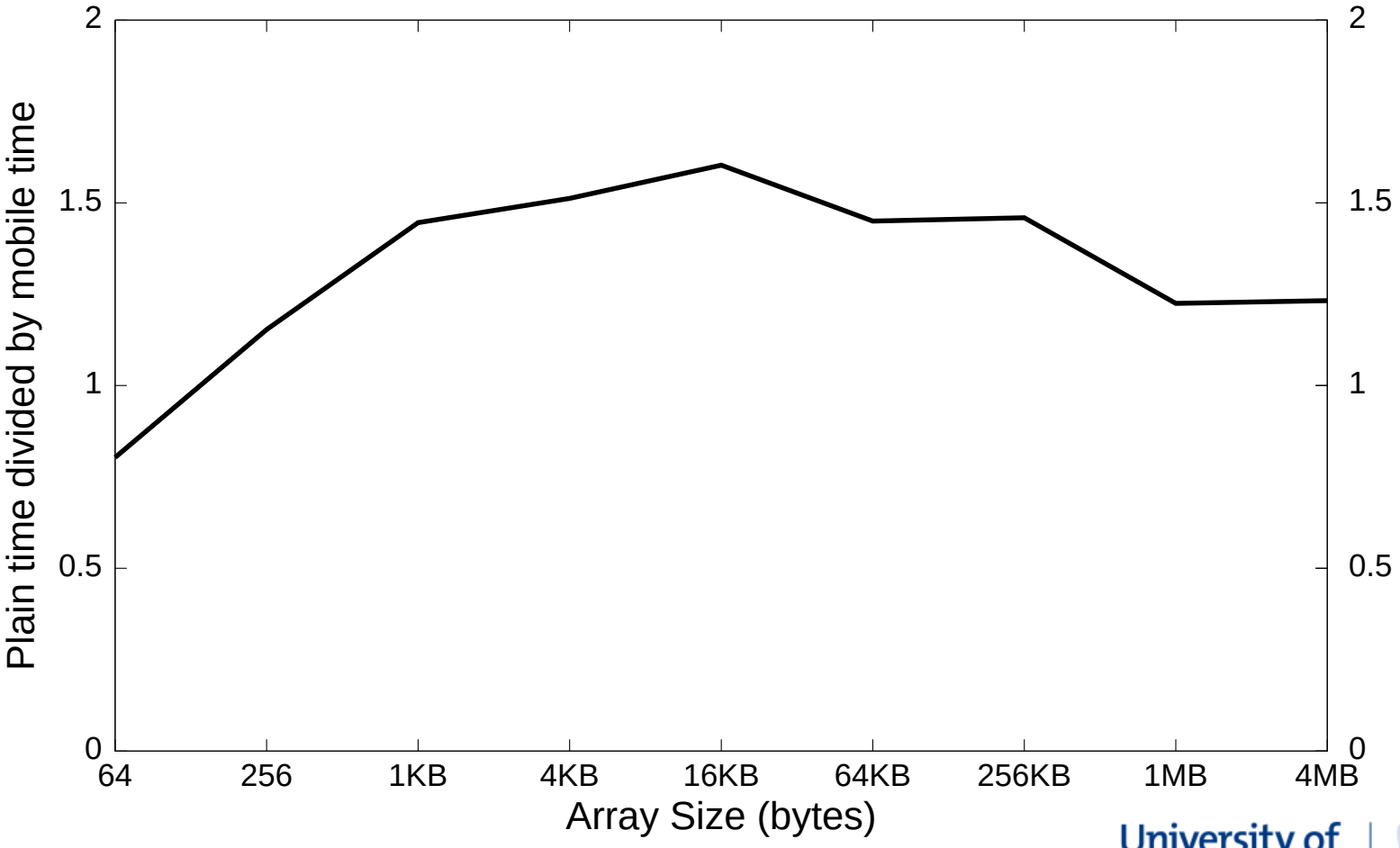
Benchmark 3 of 3: occam audio kit (oak)



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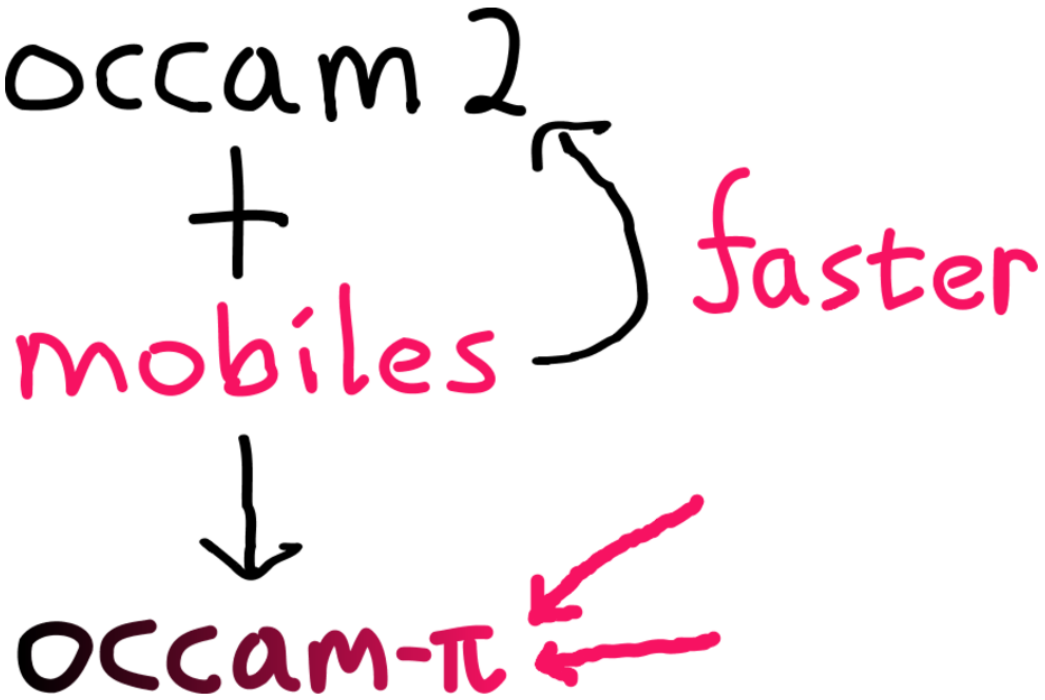
Summary



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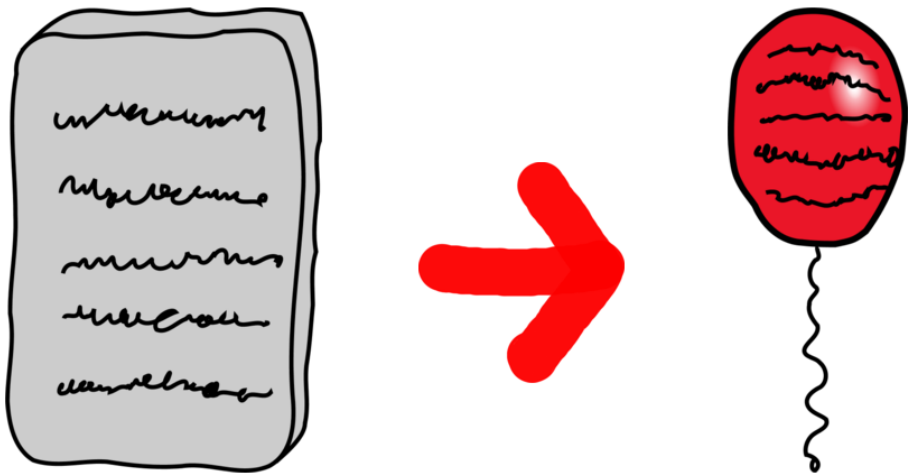

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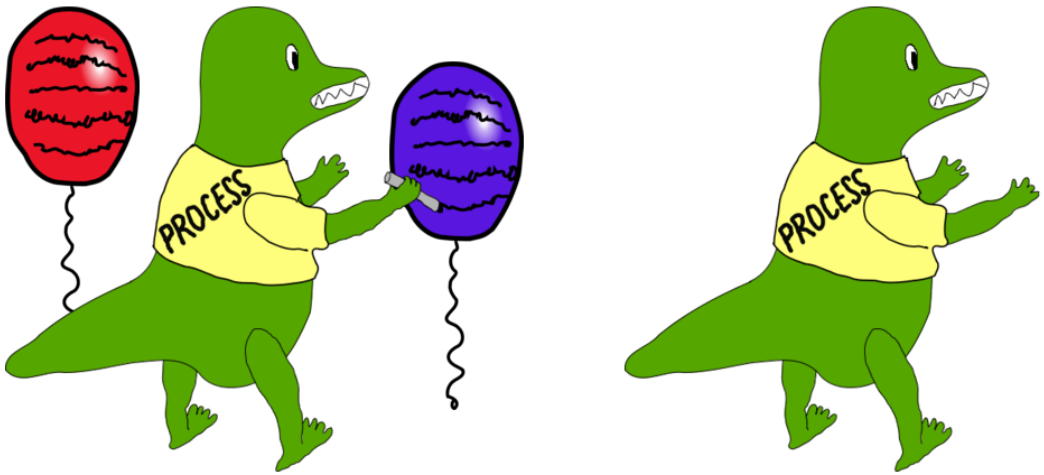
Summary

Communication



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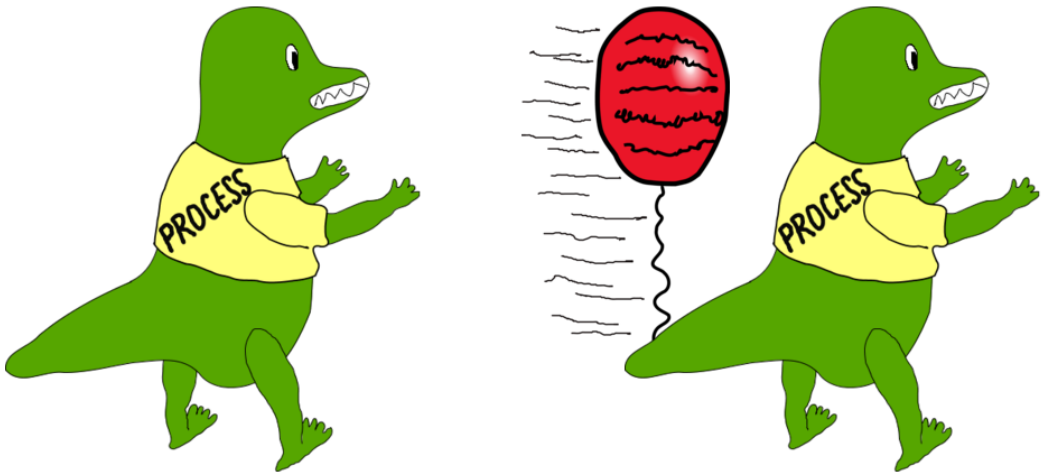

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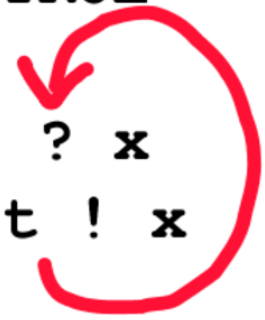

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Conclusions

- It's already in Tock, enabled by compiler flag
- Better speed and memory use than plain occam 2
- No extra programmer burden (no change to code)
- Retains simple copy semantics
- Opportunity cost of mobile data ideas (e.g. mobile atoms)
  - Can use mobile channels as tokens
- Supporting dynamically-sized arrays is now easy

Questions

Allocation vs Copying

$$c(S) > (1 - M)(c(S) + a(S))$$

$$\frac{M}{1-M} > \frac{a(S)}{c(S)}$$

Copy-on-Write