Speed and Simplicity for Incremental Sequence Computation

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What is Incremental Computation?

4 2 5 1 4 9 5 7 8 3 3 6

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max(4 2 5 1 4 9 5 7 8 3 3 6) = 9

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Change Data

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Update Result?

max(4 2 5 1 4 3 5 7 8 3 3 6) = 8

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max(4 2 5 1 4 9 5 7 8 3 3 6) = 9

Change Data

Update Result?

max(4 2 5 1 4 3 5 7 8 3 3 6) = 8

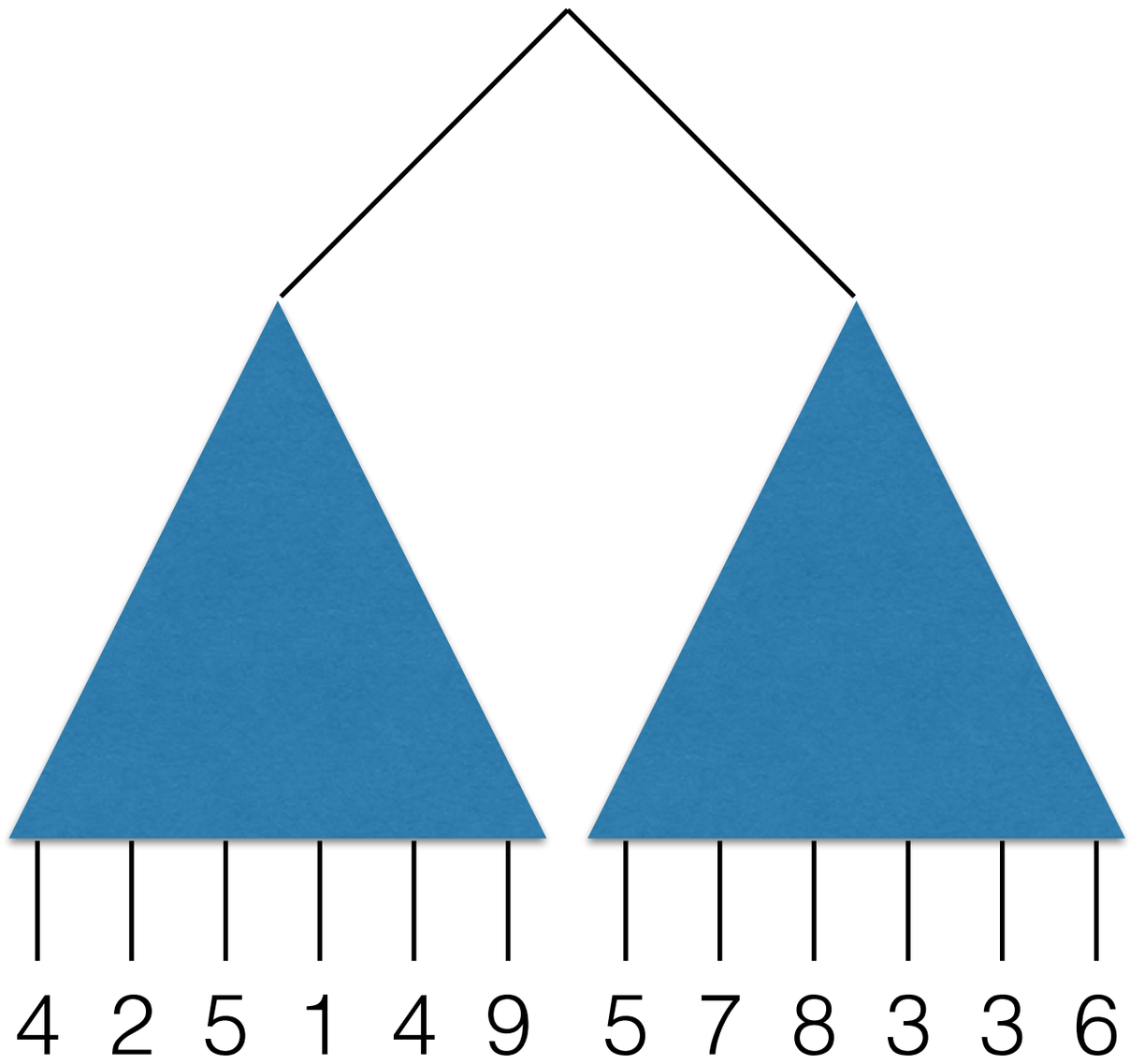
Not incremental: requires additional full scan of data

A computation is incremental if repeating it with a changed input is faster than re-computation

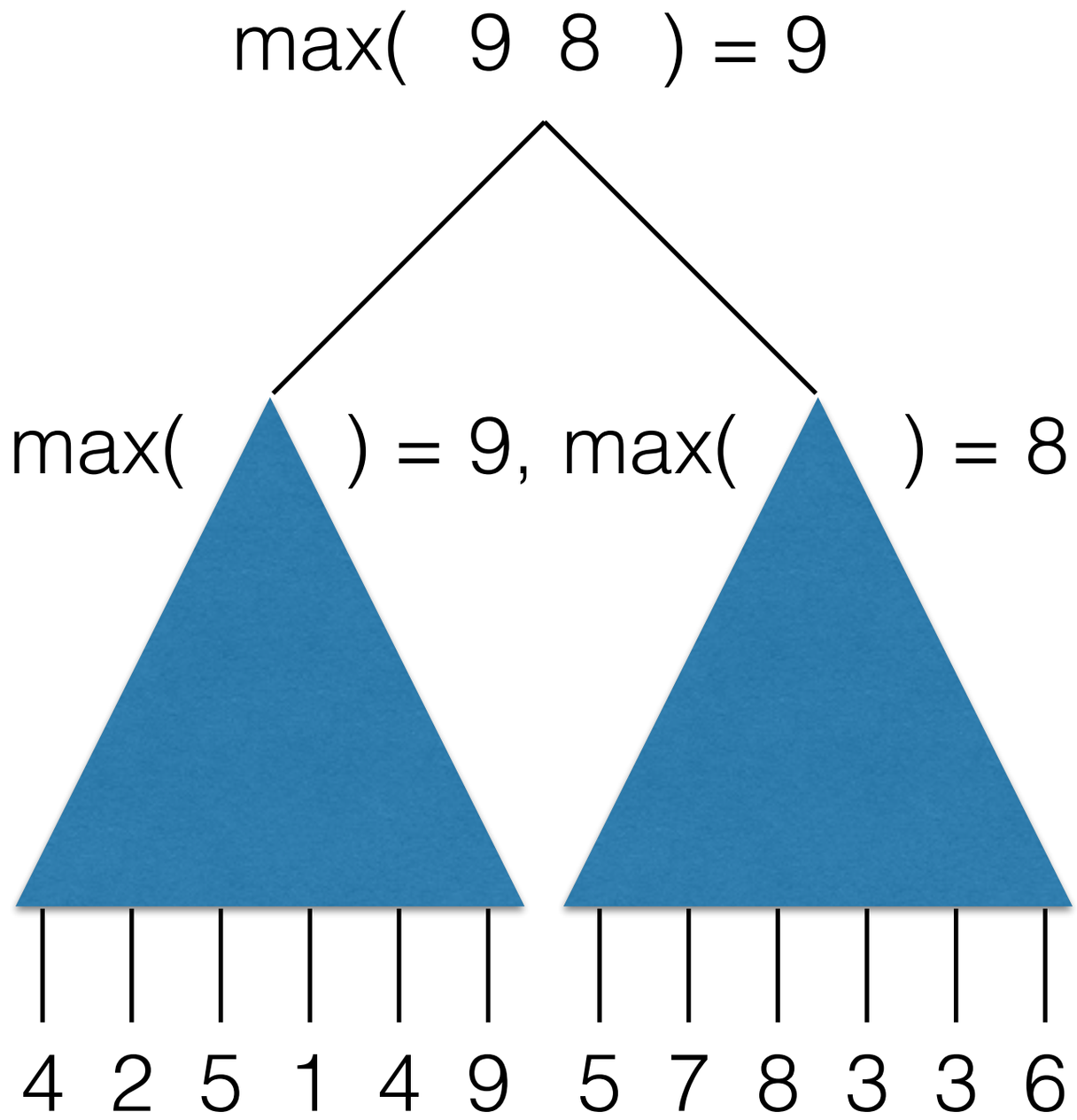
Using Memo Tables

4 2 5 1 4 9 5 7 8 3 3 6

Using Memo Tables

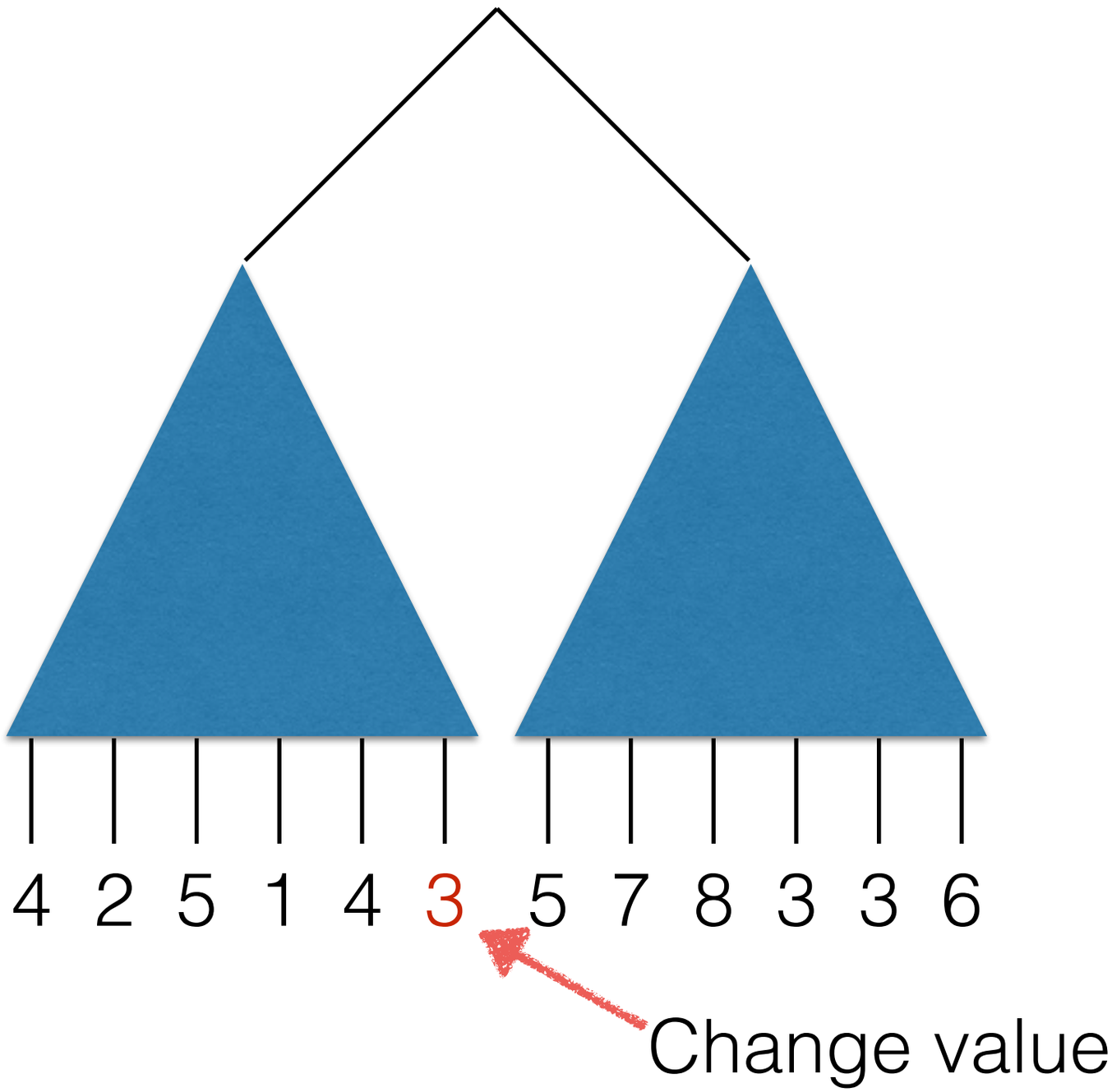


Using Memo Tables



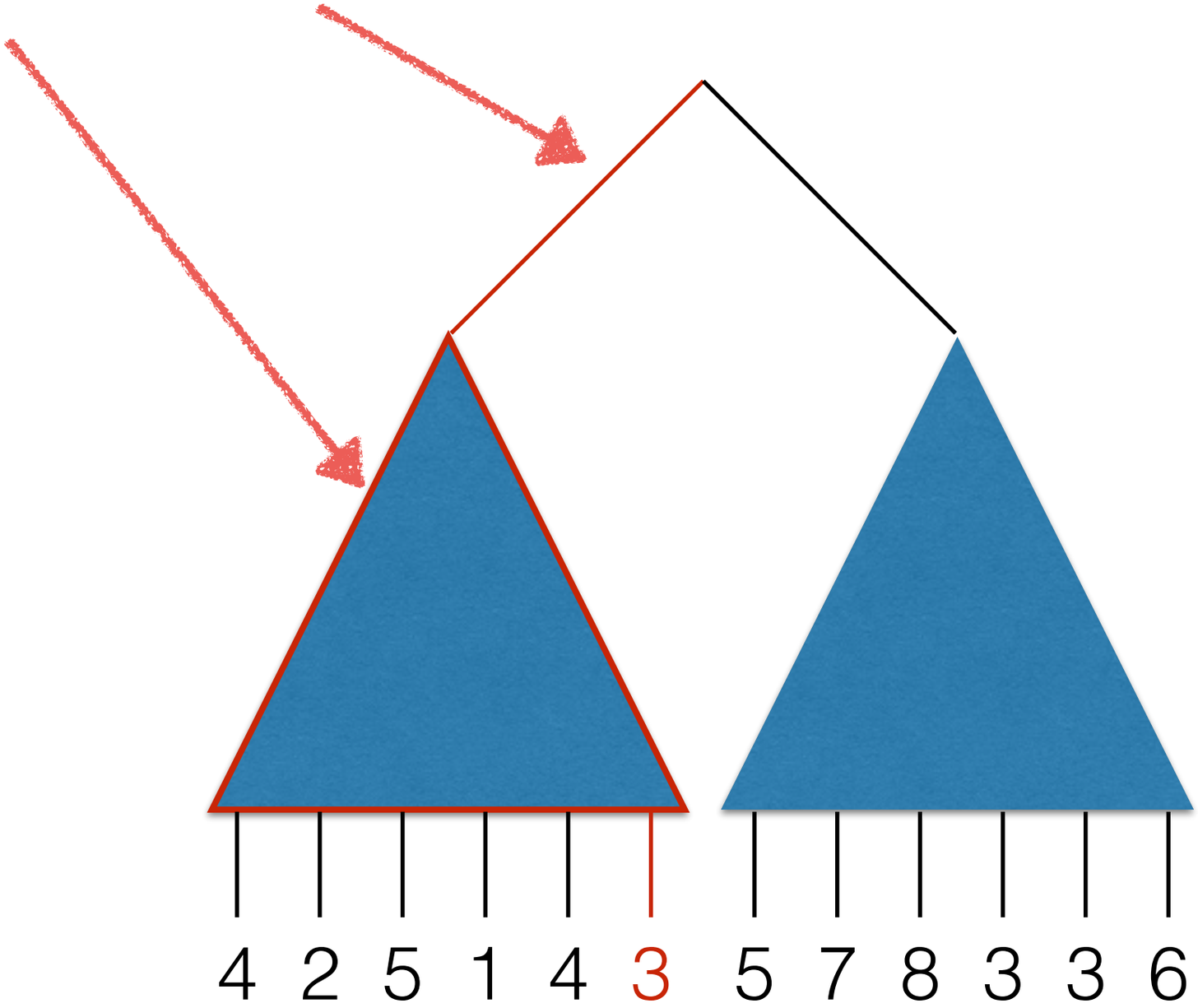
Add results to table

Using Memo Tables

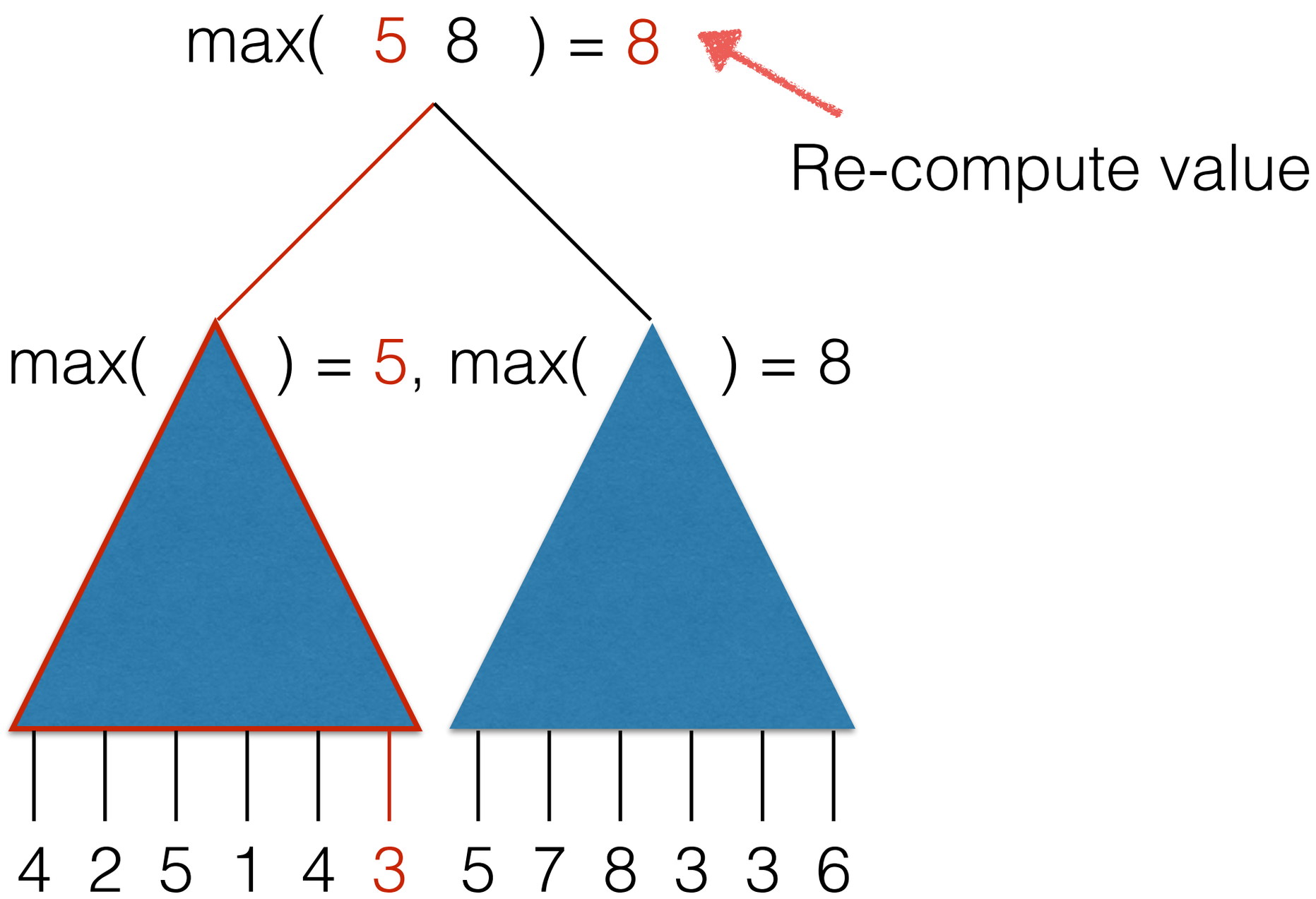


Using Memo Tables

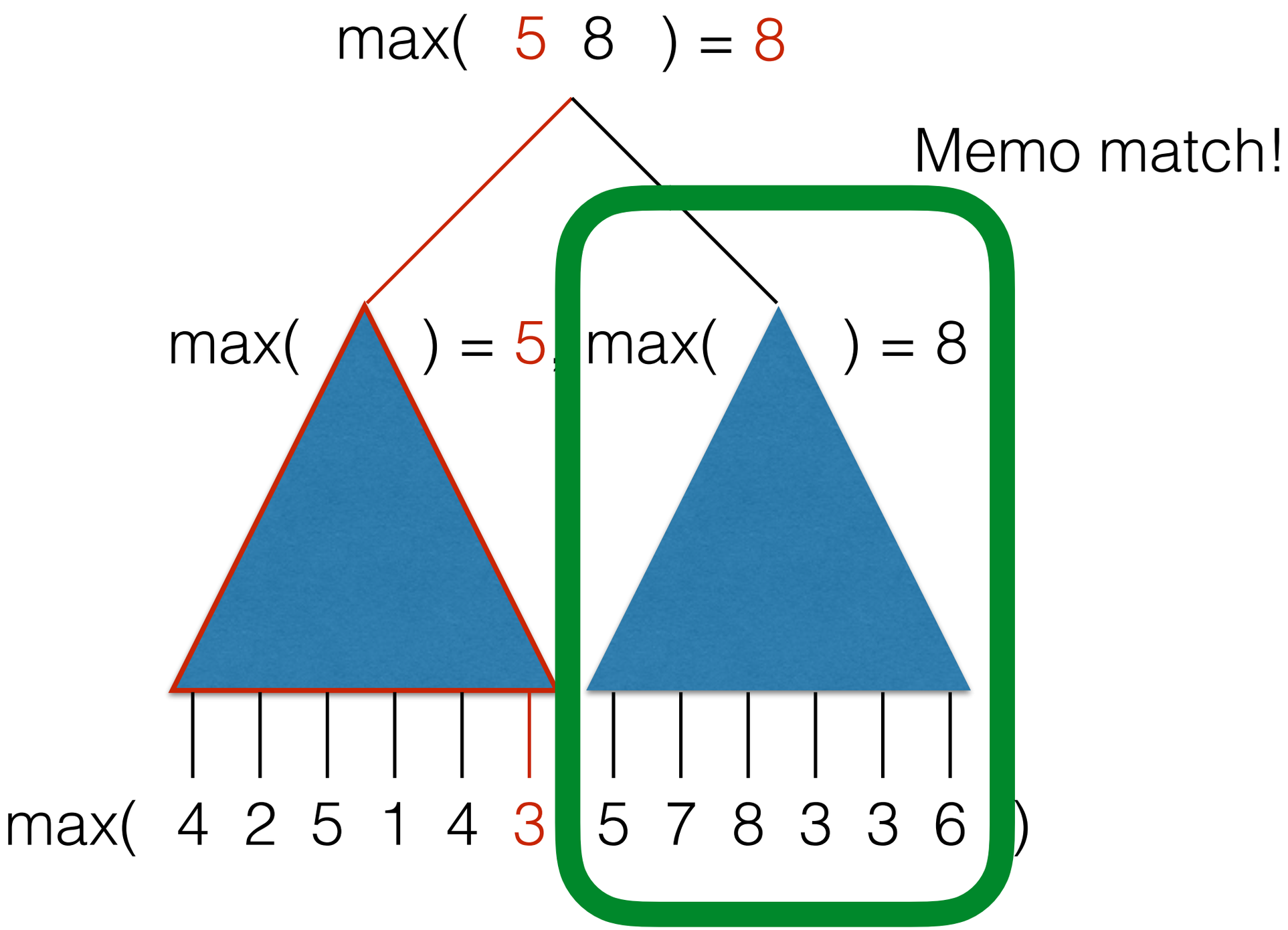
Update persistent tree



Using Memo Tables



Using Memo Tables



Language-based Incremental Computation

Reason about the non-incremental computation

Make calls to library functions for data access

Internally, the library makes use of:

Cached values

Dependency graphs

Research challenge

How do we advance the use of incremental computation, further simplifying code creation and providing speedups over realistic code?

Speed Problem

How do we advance the use of incremental computation, further simplifying code creation and providing speedups over realistic code?

www.rust-lang.org

Documentation Install Community Cont

Rust is a systems programming language that runs blazingly fast, prevents segfaults, and guarantees thread safety.

Inst

Speed Problem

Incremental performance improved

Non-Incremental performance improved a lot more

Speed Problem

Computers are better at adding and subtracting numbers than walking through memory

Speed Problem

Computers are better at adding and subtracting numbers than walking through memory

Incremental computation libraries manage a lot of memory

Speed Problem

Computers are better at adding and subtracting numbers than walking through memory

With optimized code, it's faster to re-compute subproblems than to manage them

Iodyn

Incremental Collections Library
Based on Adapton

github.com/cuplv/iodyn.rust

rust crate: iodyn

Giraz - Incremental sequences

In progress: Tries, Graphs

Giraz

Incremental Sequence data structure

Based on Adapton

Based on RAZ data structure

Includes incremental functions

Insert

Delete

Move cursor

fold_up -
tree fold, compute at leaf and binary nodes

fold_lr -
list fold, compute at each element

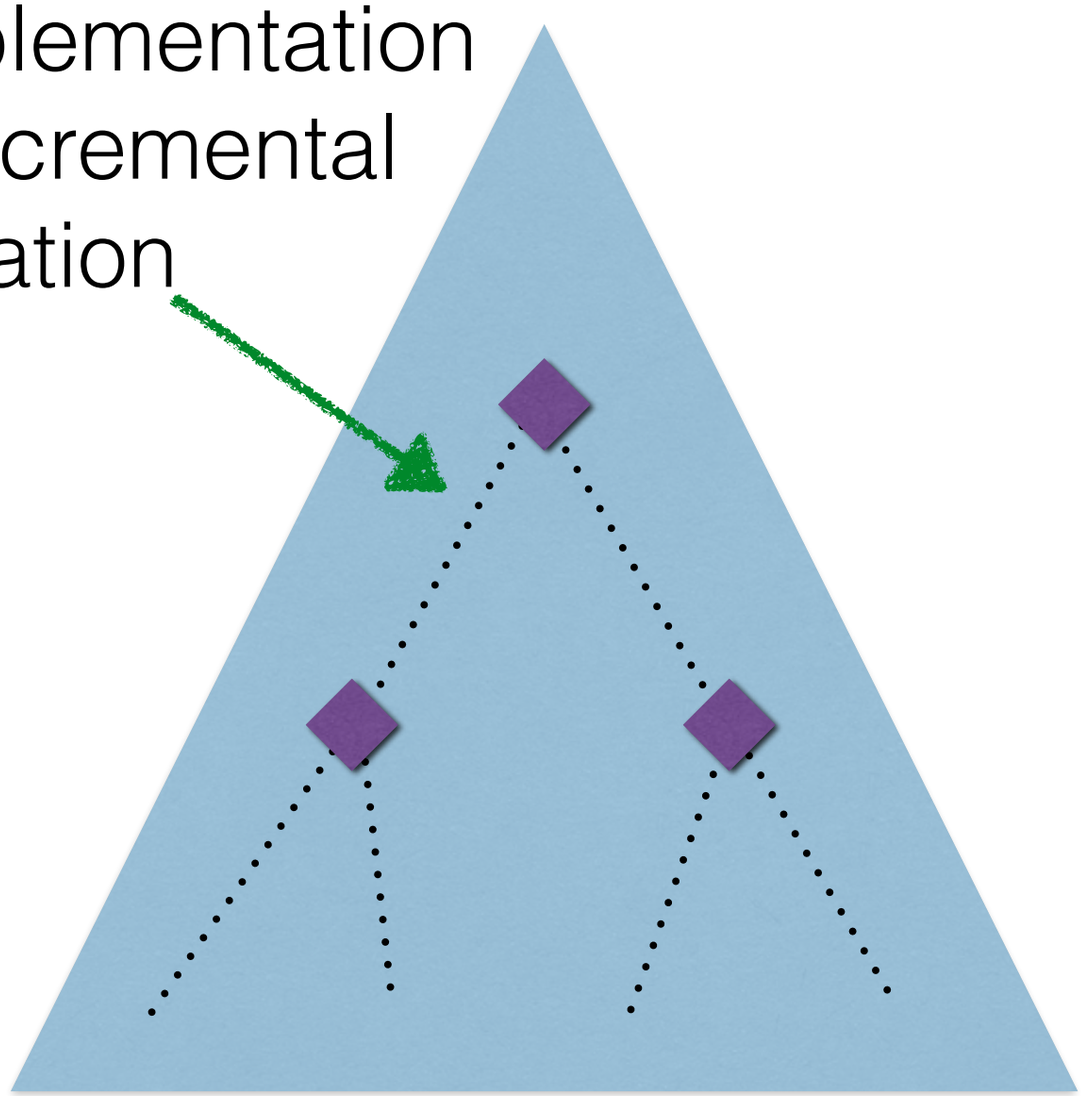
map -
maintain structure and transform each element

What is a Giraz?

Sequence: 

What is a Giraz?

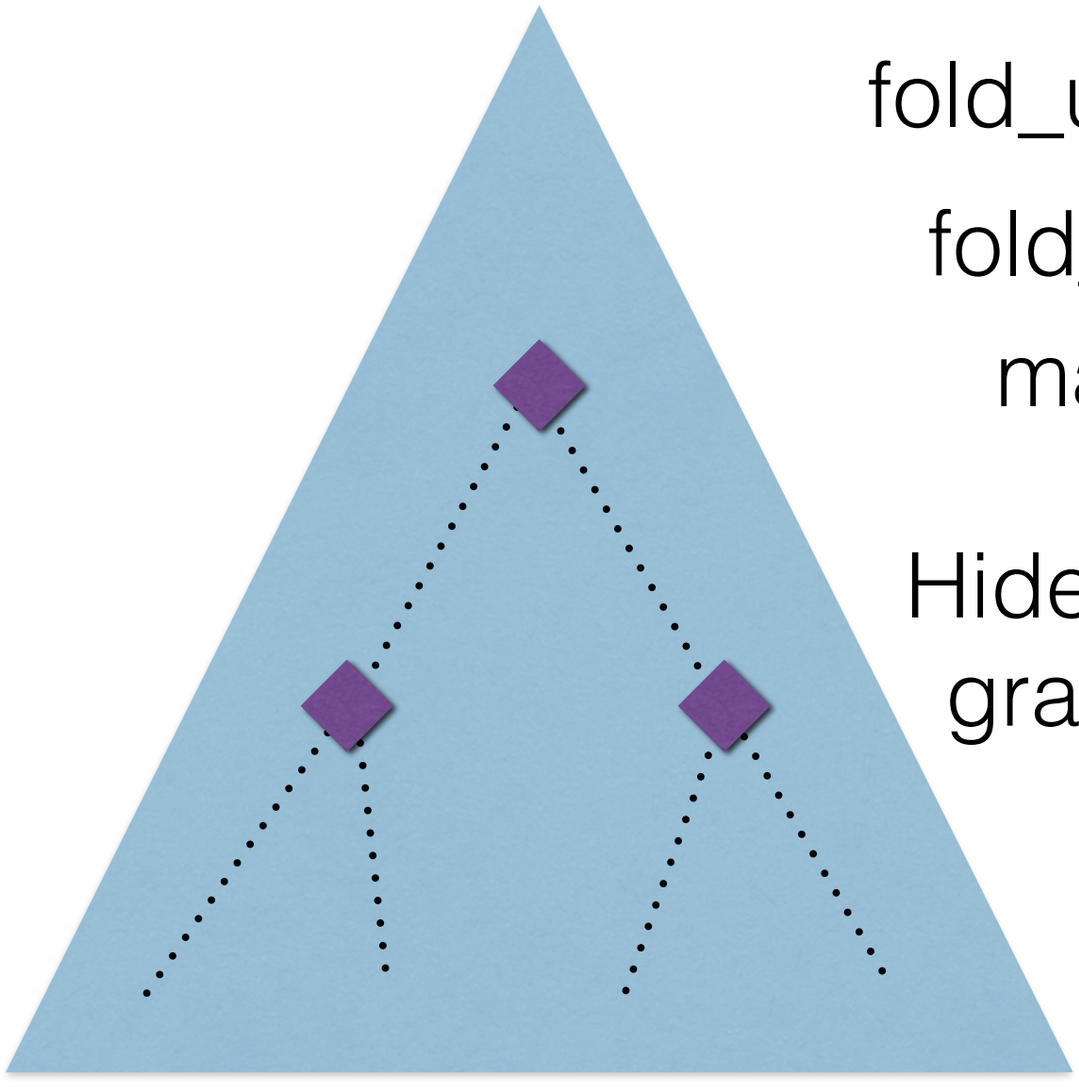
Tree-based implementation for efficient incremental computation



Sequence:

What is a Giraz?

Higher-order collections combinators



fold_up()

fold_lr()

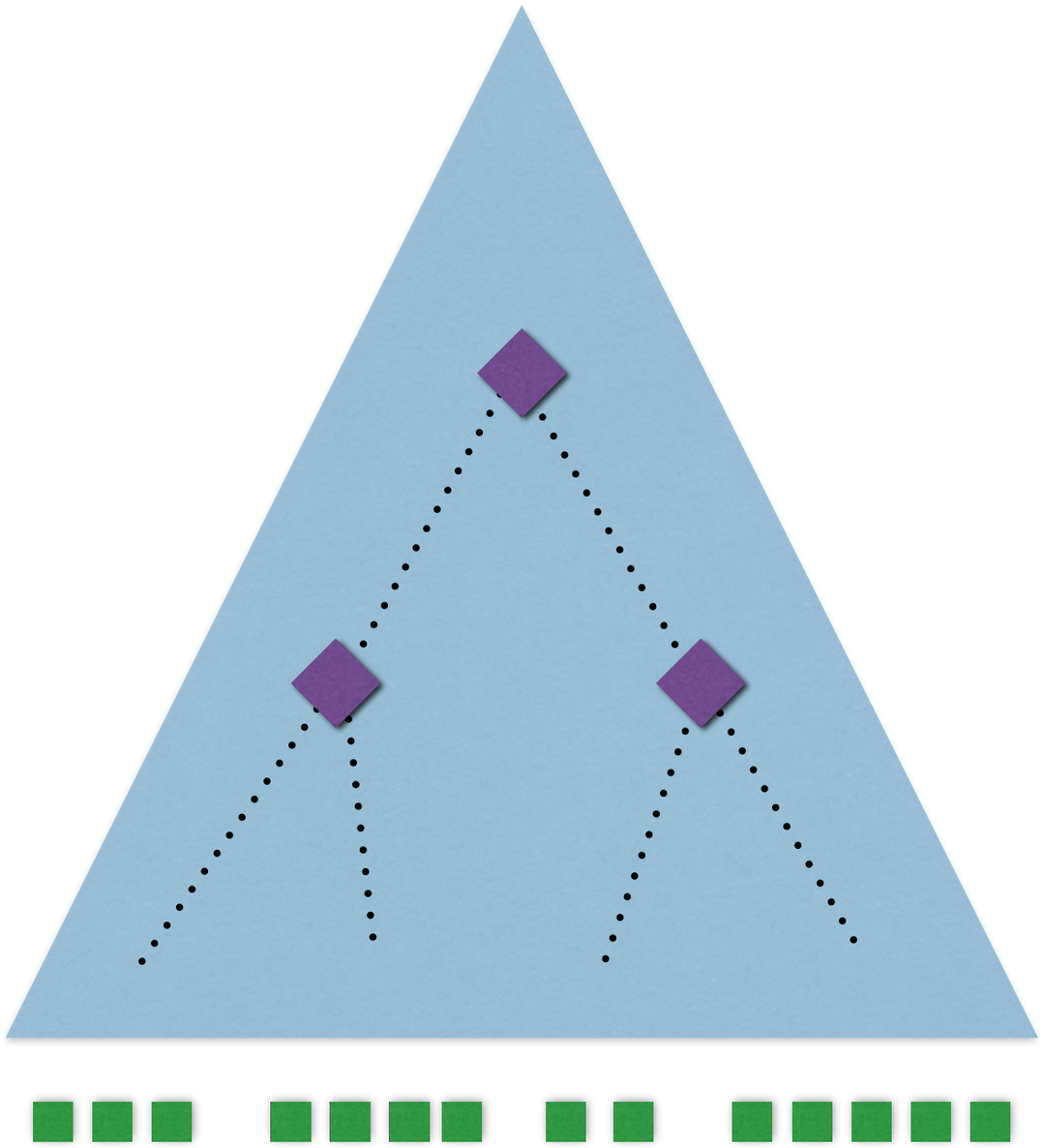
map()

Hides the dependency graphs from the user

Sequence:

What is a Giraz?

Allows user control over subproblem size



What is a Giraz?

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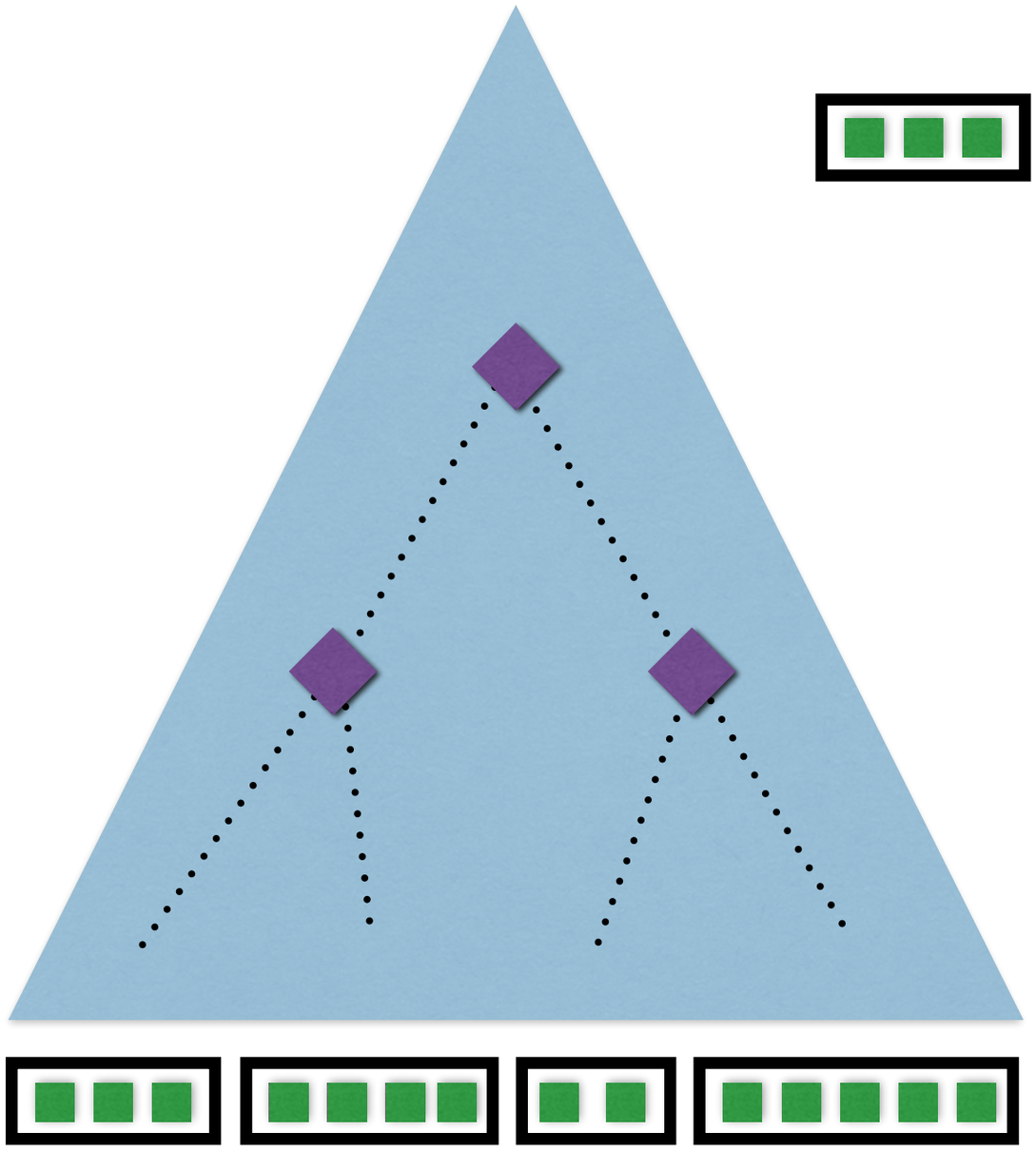
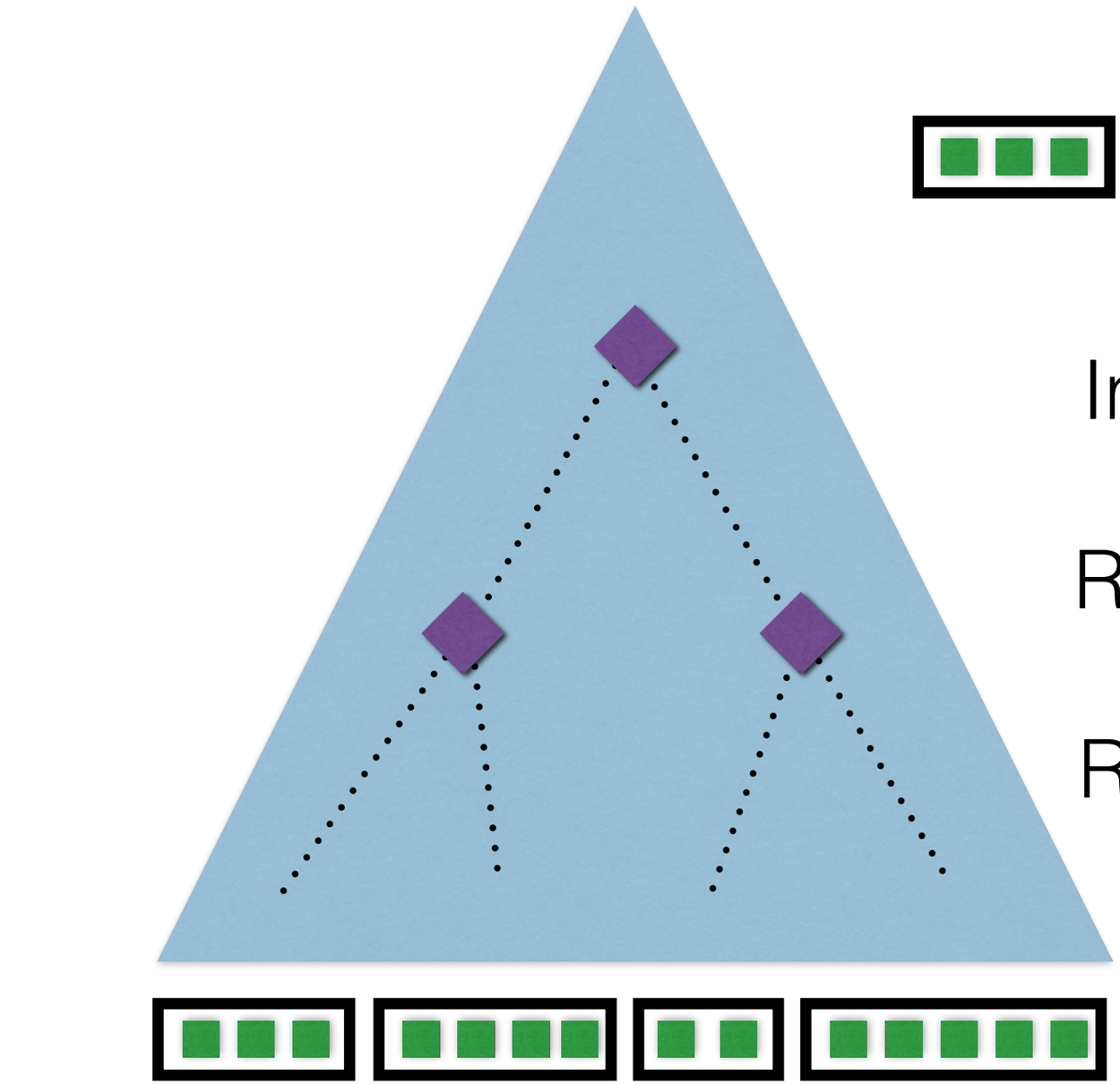


Native Arrays

Group the data into subsequences

What is a Giraz?

Allows user control over subproblem size



Native Arrays

Improve cache coherence

Reduce incremental overhead

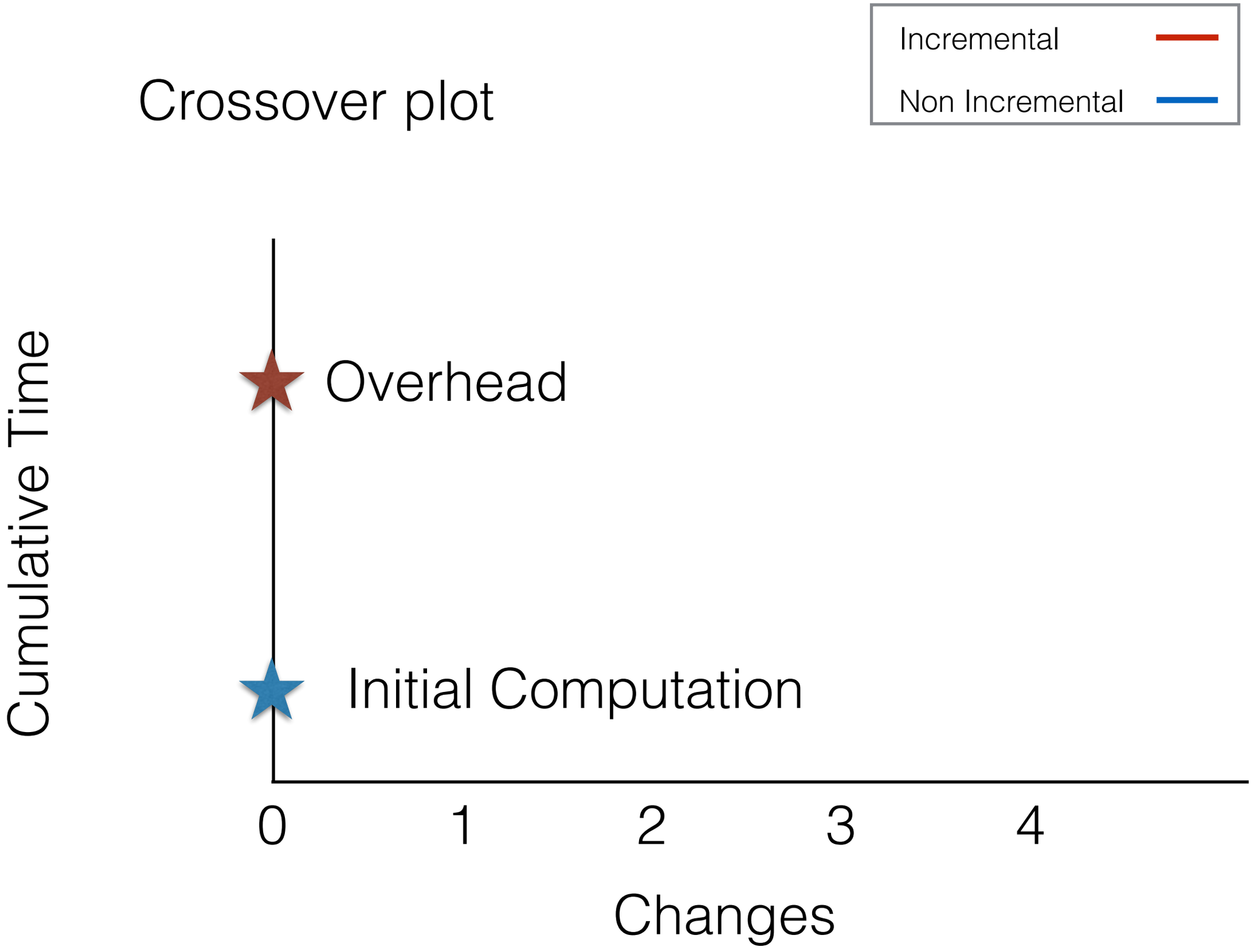
Requires management

Group the data into subsequences

Experimental Evaluation

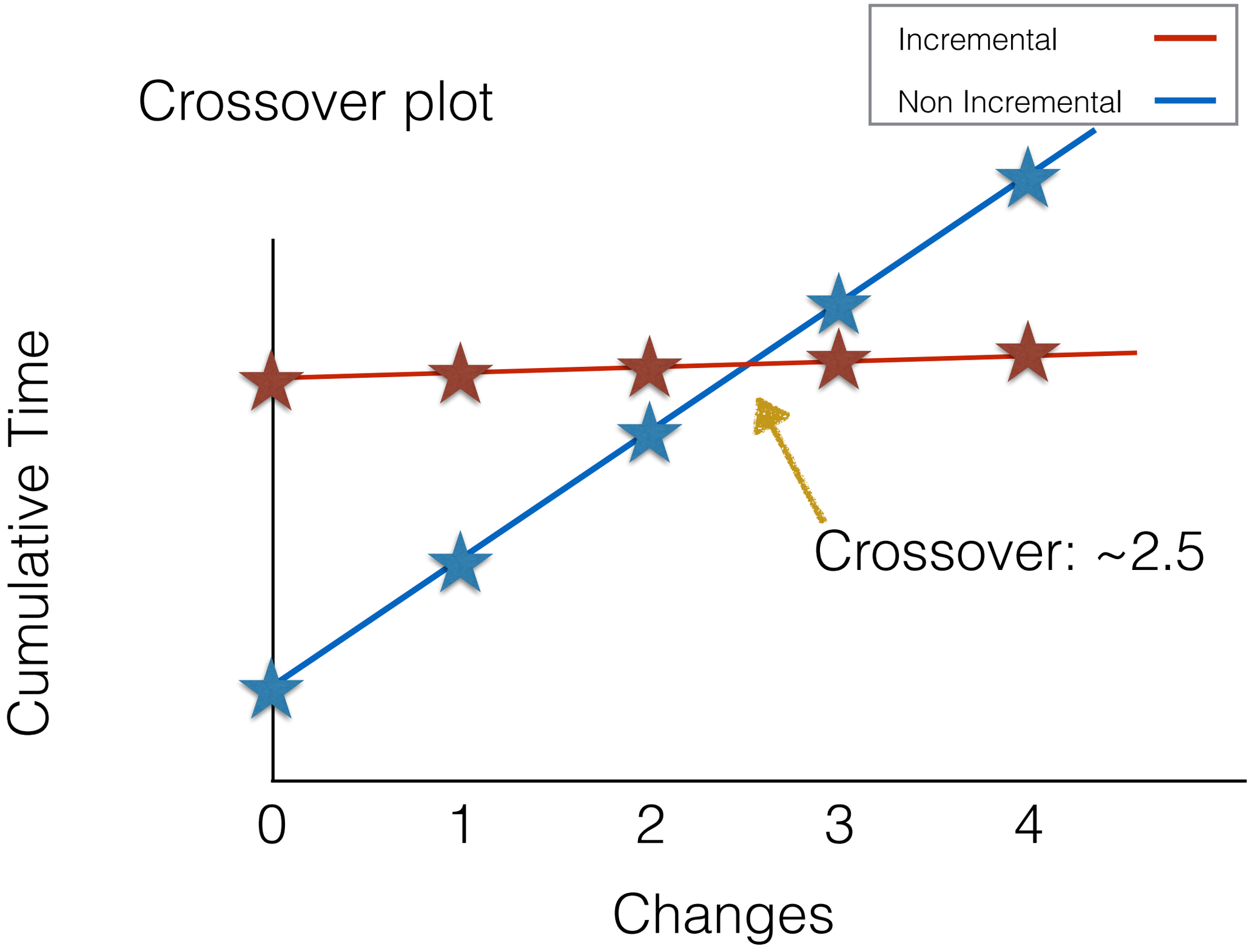
Experimental Evaluation

Crossover plot



Experimental Evaluation

Crossover plot



Experimental Evaluation

Compute max of a collection

Non-Incremental

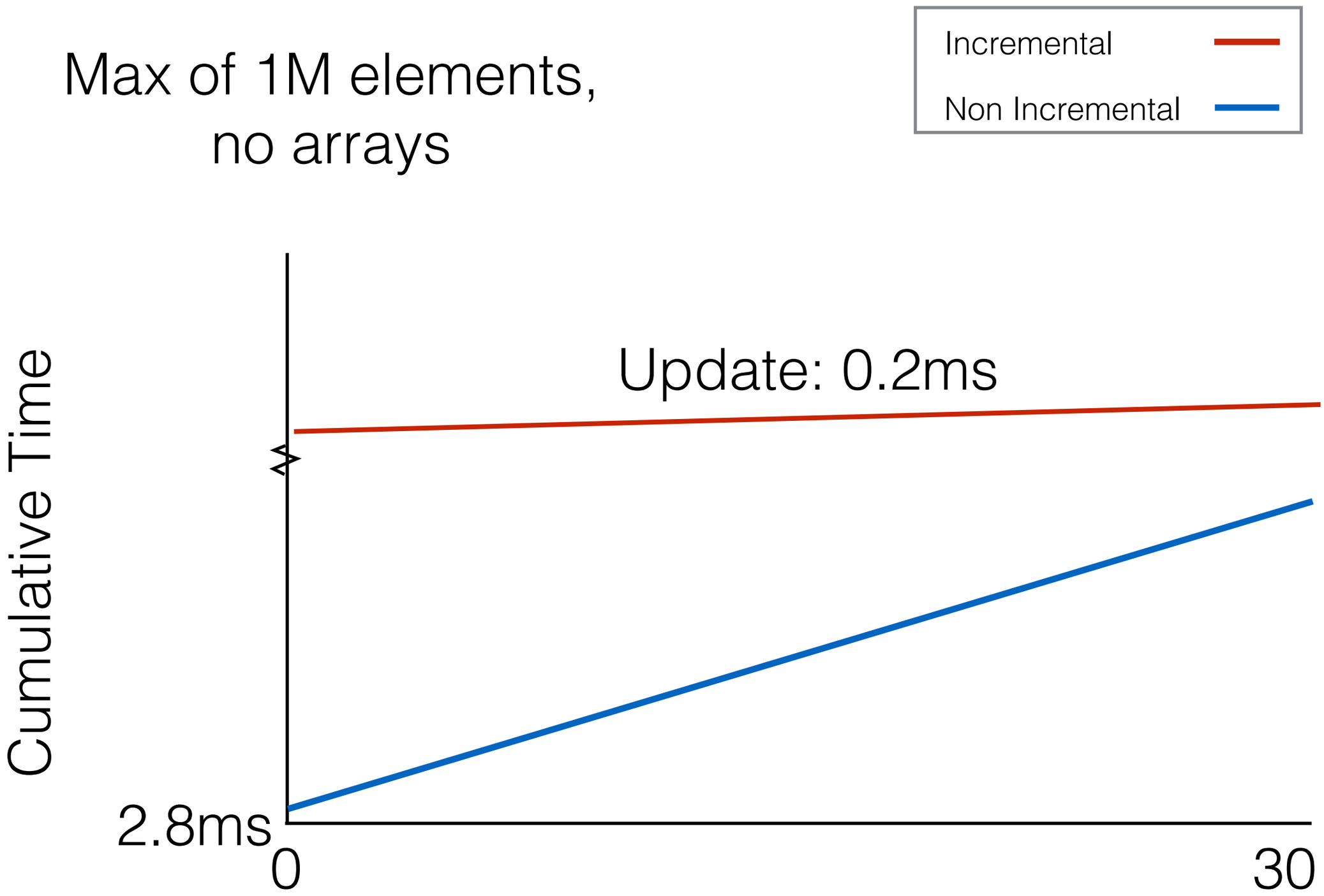
```
inputvec.iter().max()
```

Incremental

```
inputgiraz.fold_up(λx.match x {
  Leaf(vec) => vec.iter().max(),
  Bin(m1,m2) => max(m1,m2)
})
```

Experimental Evaluation

Max of 1M elements,
no arrays



Experimental Evaluation

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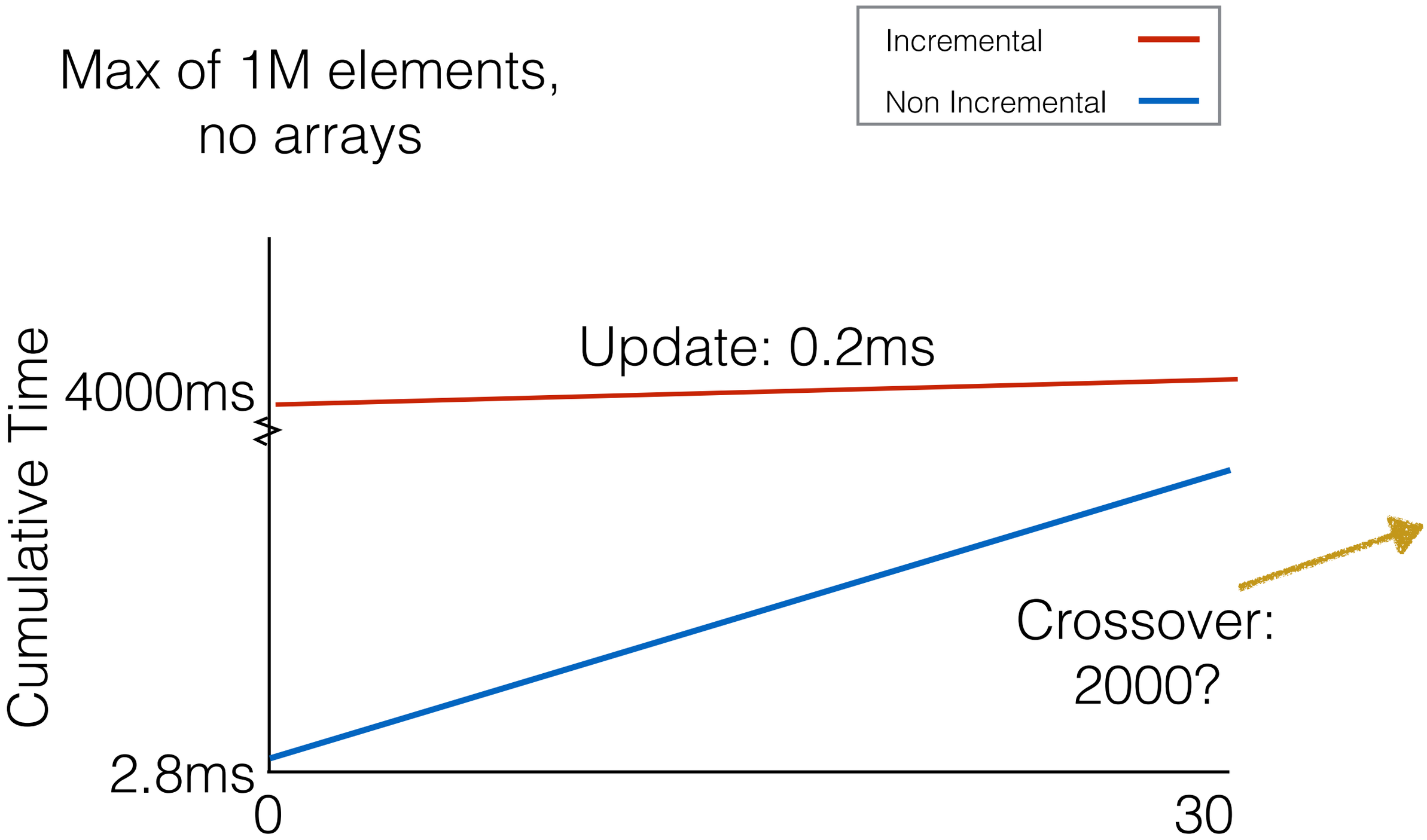
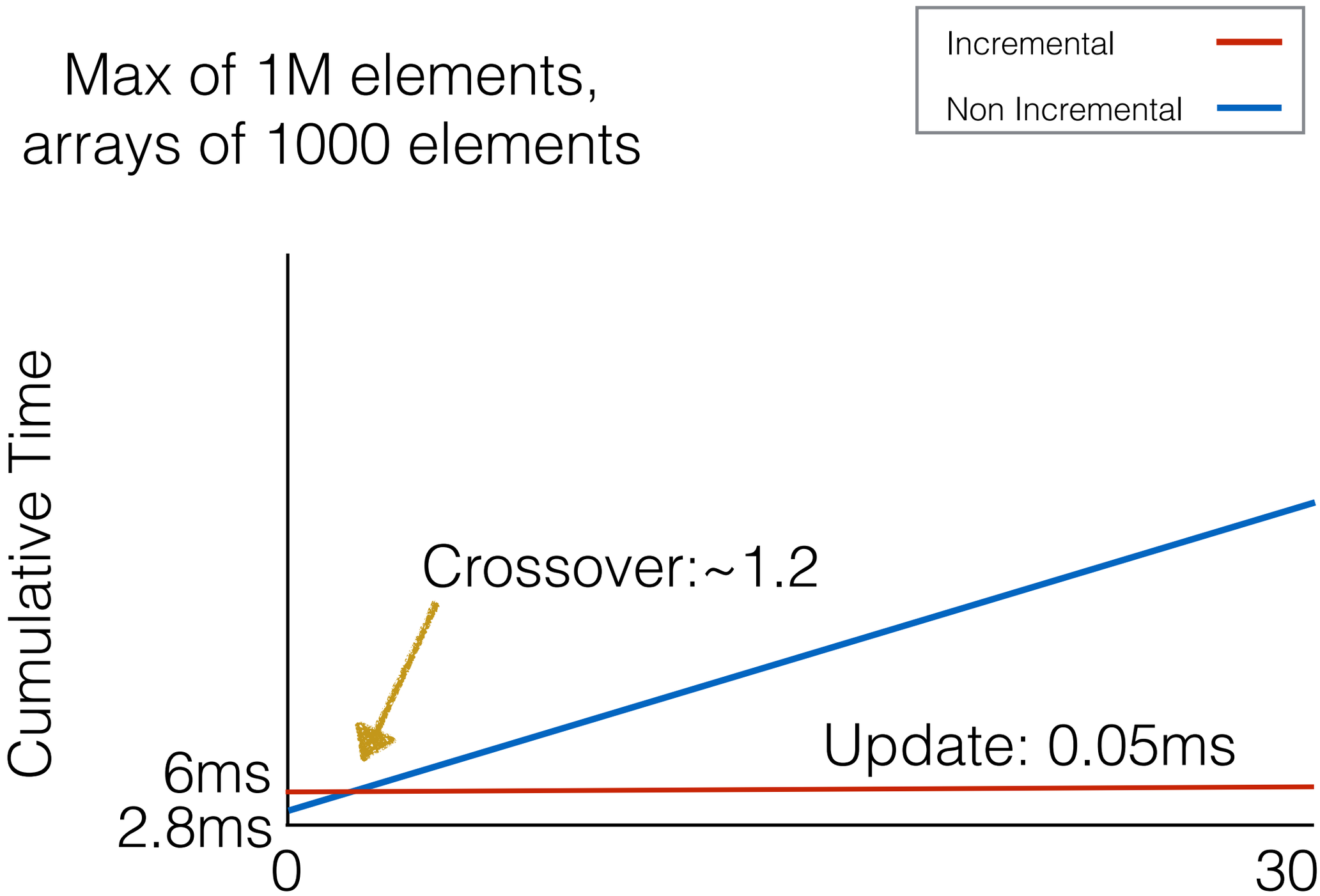


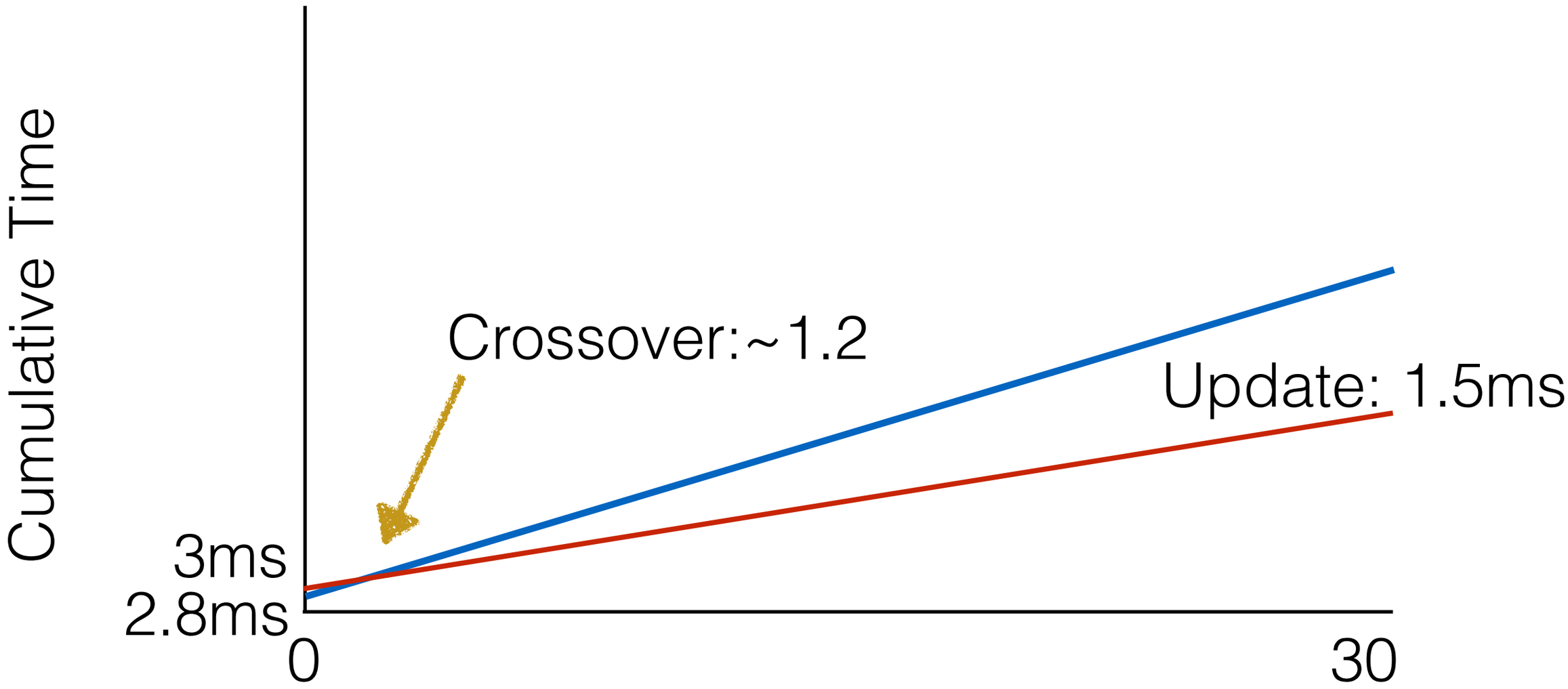
Experimental Evaluation

Max of 1M elements,
arrays of 1000 elements



Experimental Evaluation

Max of 1M elements,
arrays of 500k elements



All inputs: 1M, gauges 1k, times in ms

	Native initial	inc initial	inc update	crossover	speedup
max	2.84	5.99	0.05	2	57.5
quickhull	56.6	213	13.5	6	4.20
adder	10.3	91.1	0.43	10	23.9
to_string	93.8	95.5	0.21	1	449
reverse	2.01	7.85	0.09	4	22.2

github.com/cuplv/iodyn.rust

```
cd eval, cargo run --release --example [name] -- [options]
```

Summary

Development of an incremental computation library where the user writes non-incremental code

This library is competitive with native rust code

The api allows the user to specify subsequences, which can tune performance to a particular application

Code is available on Github, and can be imported into rust projects through the standard package manager

www.github.com/cuplv/iodyn.rust

kyleheadley.github.io