École Polytechnique Fédérale de Lausanne

Master Thesis

Relaxed Radix Balanced Trees as Imutable Vectors Scala

Author:
Nicolas Stucki

Supervisor:
Vlad Ureche

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Abstract

School of Computer and Communications
Computer Science

Master in Computer Science

Relaxed Radix Balanced Trees
as Imutable Vectors Scala

by Nicolas Stucki

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too…

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Abbreviations

JIT	**J**ust **I**n **T**ime
RB	**R**adix **B**alanced
RRB	**R**elaxed **R**adix **B**alanced

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Chapter 1

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1.1.1 Subsection 1

1.1.2 Subsection 2

1.2 Main Section 2

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Chapter 2

Vector Structure

2.1 Radix Balanced Vectors

2.1.1 Tree structure

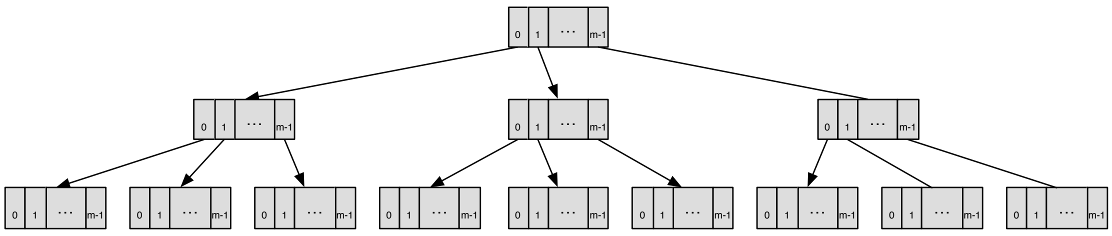

FIGURE 2.1: Radix Balanced Tree Structure

2.1.2 Operations

2.1.2.1 Apply (get element at index)

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Append and Prepend

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2.3.1 Tree structure

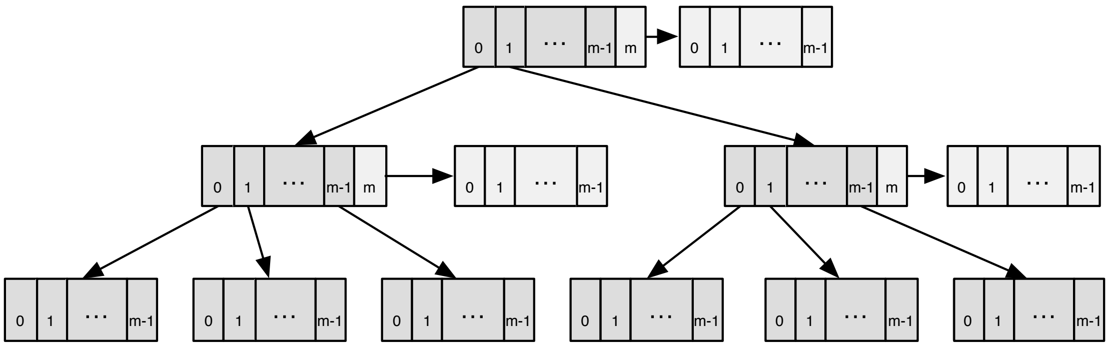

FIGURE 2.2: Radix Balanced Tree

2.3.2 Operations

2.3.2.1 Apply (get element at index)

2.3.2.2 Updated

2.3.2.3 Additions

Append and Prepend

Insert

Concatenation

2.3.2.4 Splits

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Chapter 3

Implementation and Optimizations

3.1 Where does time go?

3.1.1 Arrays

3.1.2 Computing indices

$$526843 = 00\,\underbrace{00000}_{0}\,\underbrace{00000}_{0}\,\underbrace{10000}_{16}\,\underbrace{00010}_{2}\,\underbrace{01111}_{15}\,\underbrace{11011}_{27}$$

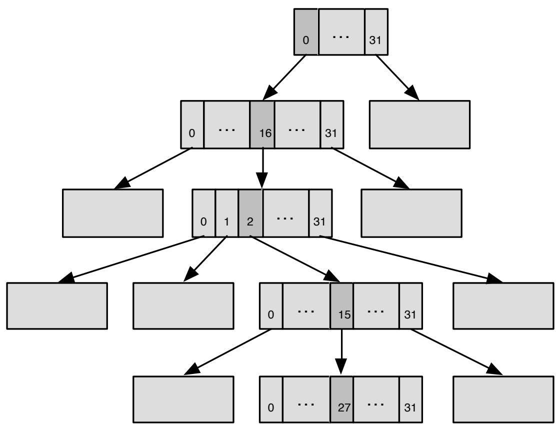

FIGURE 3.1: Accessing element at index 526843 in a tree of depth 5. Empty nodes represent collapses subtrees.

3.2 Displays

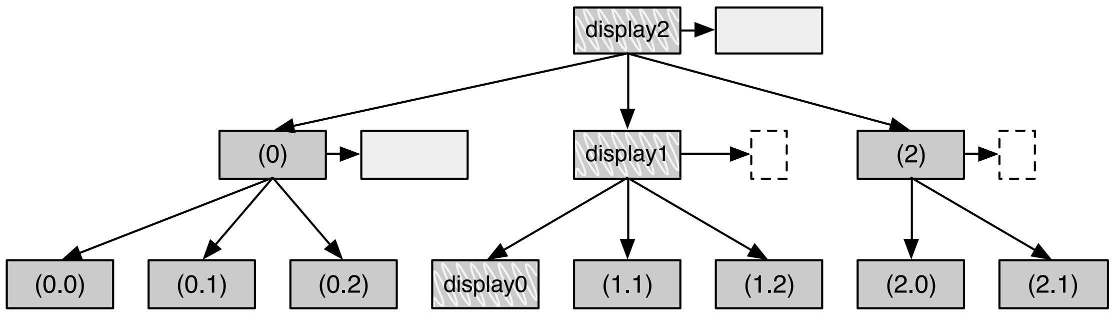

Figure 3.2: Radix Balanced Tree

3.2.1 As cache

3.2.2 For transient states

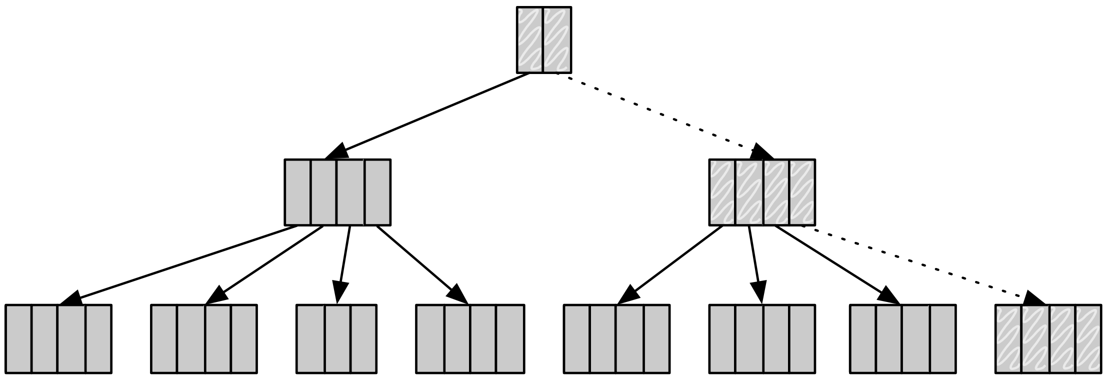

Figure 3.3: Radix Balanced Tree Transient state

3.3 Builder

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3.5 Relaxing the Radix

3.5.1 Displays

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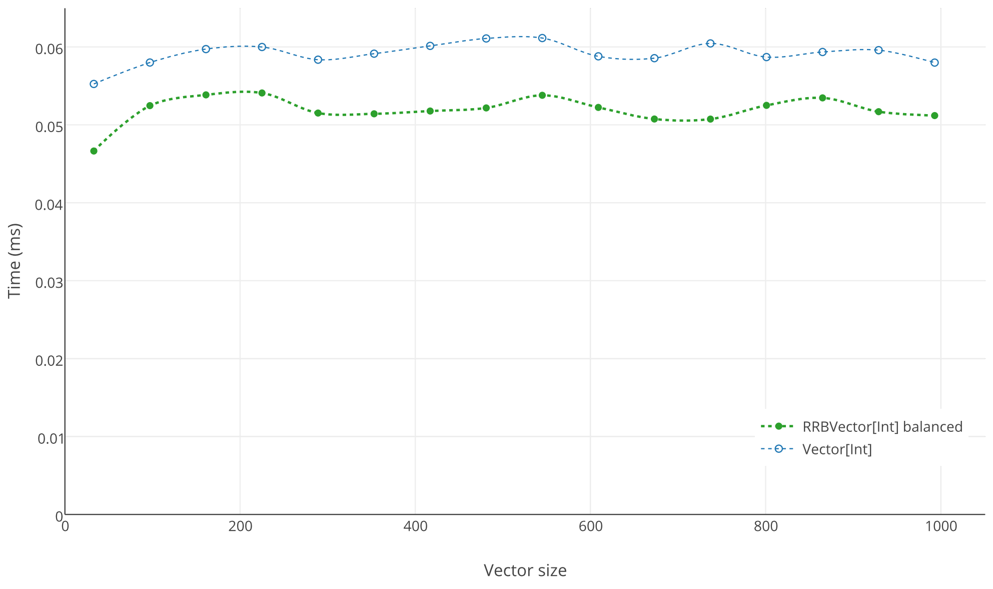


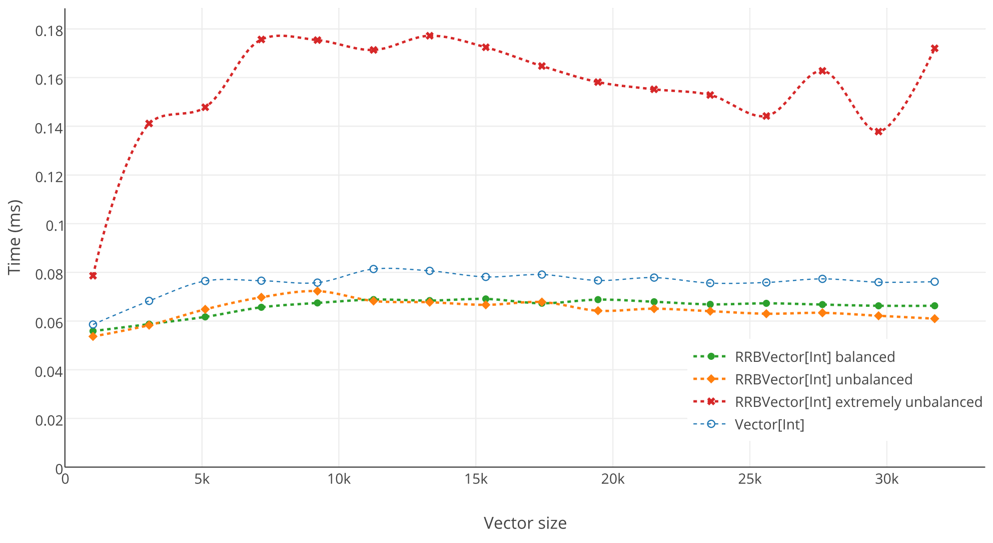


FIGURE 4.1: Time to execute 10k apply operations on sequential indices.

Chapter 4

Performance

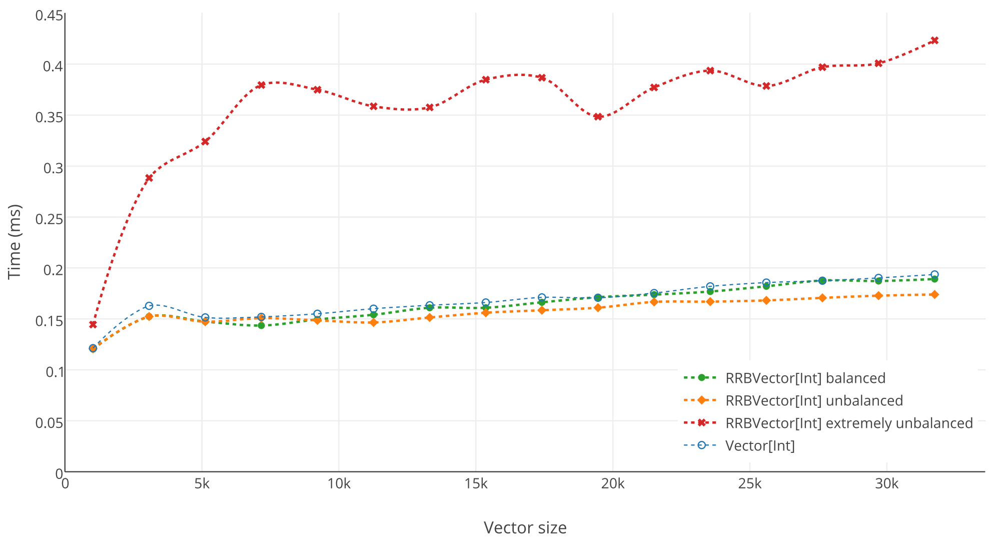


FIGURE 4.2: Time to execute 10k apply operations on random indices.

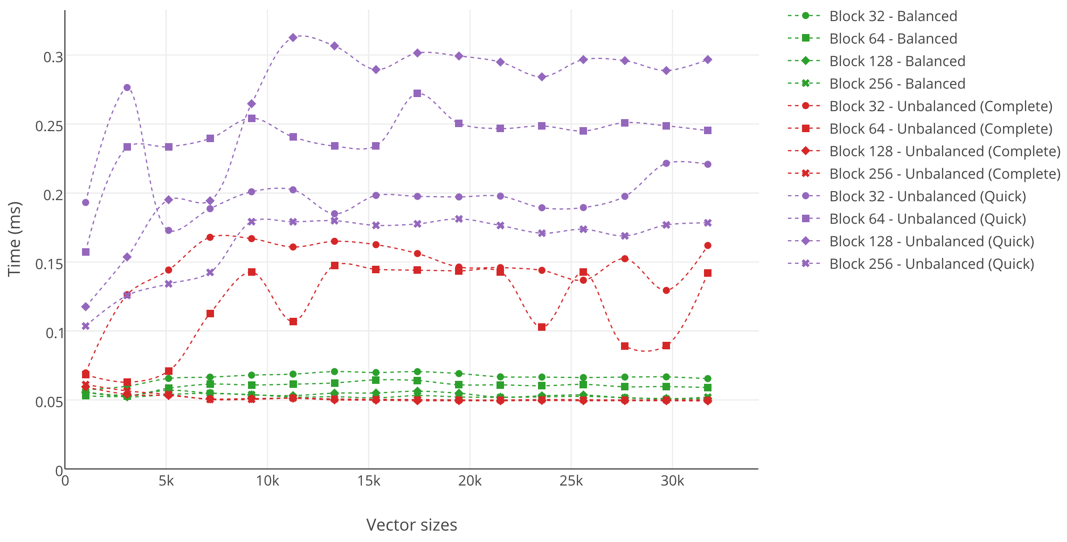
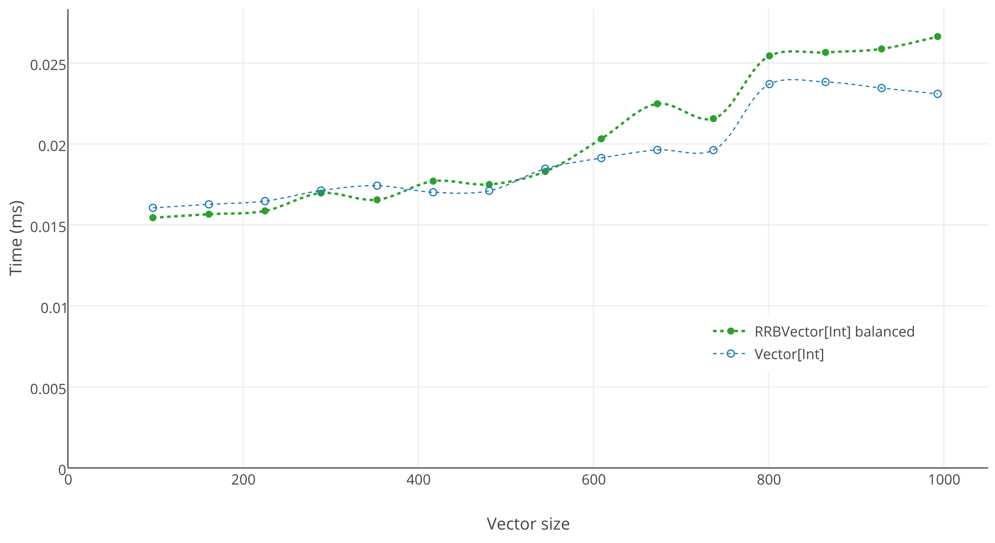


FIGURE 4.3: Time to execute 10k apply operations on sequential indices. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Copmlete/Quick).



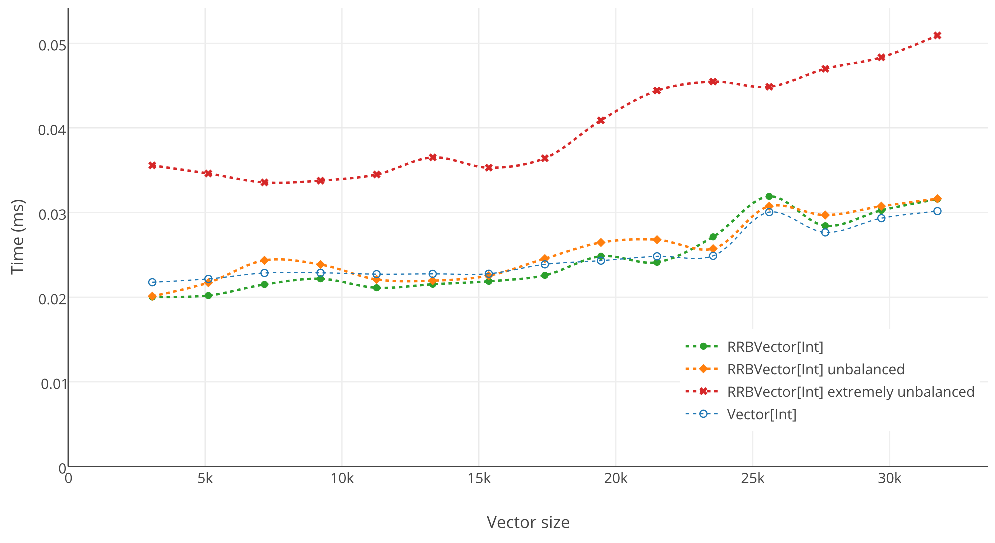


Figure 4.4: Time to execute 256 append operations. This shows the amortized cost of the append operation.

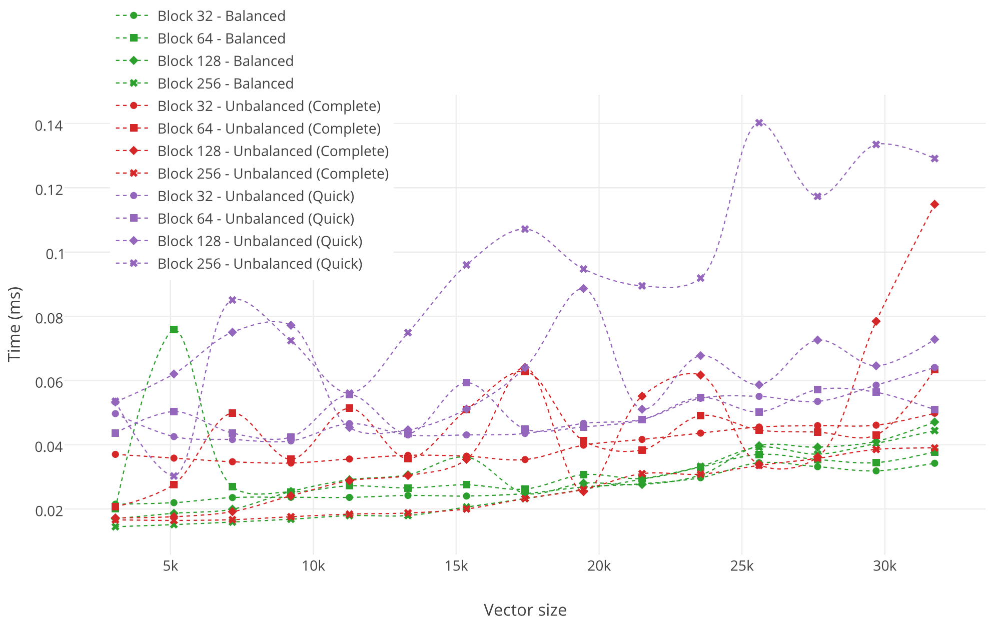
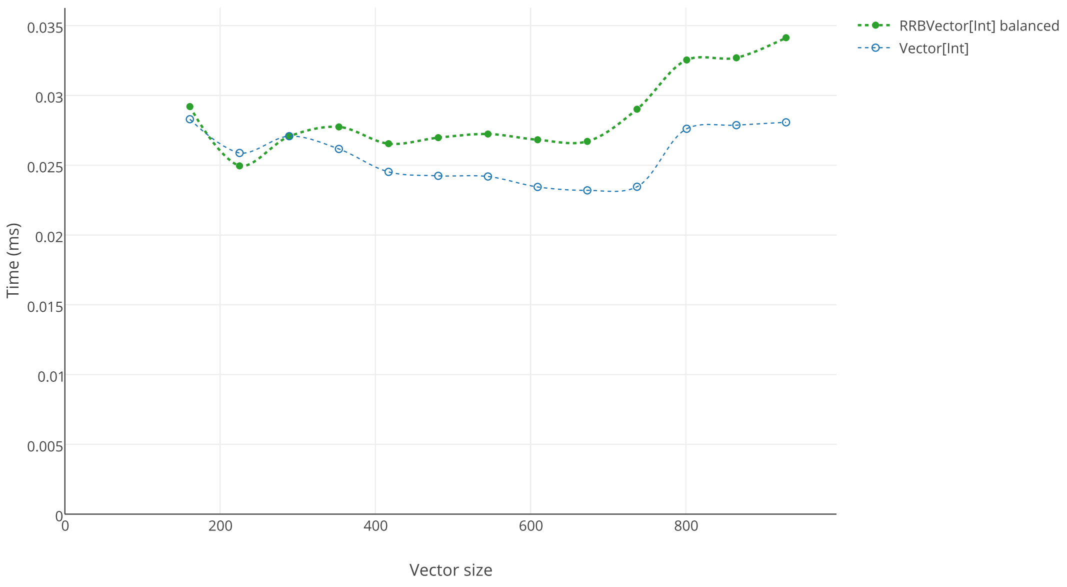


FIGURE 4.5: Time to execute 256 append operations. This shows the amortized cost of the append operation. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Copmlete/Quick).



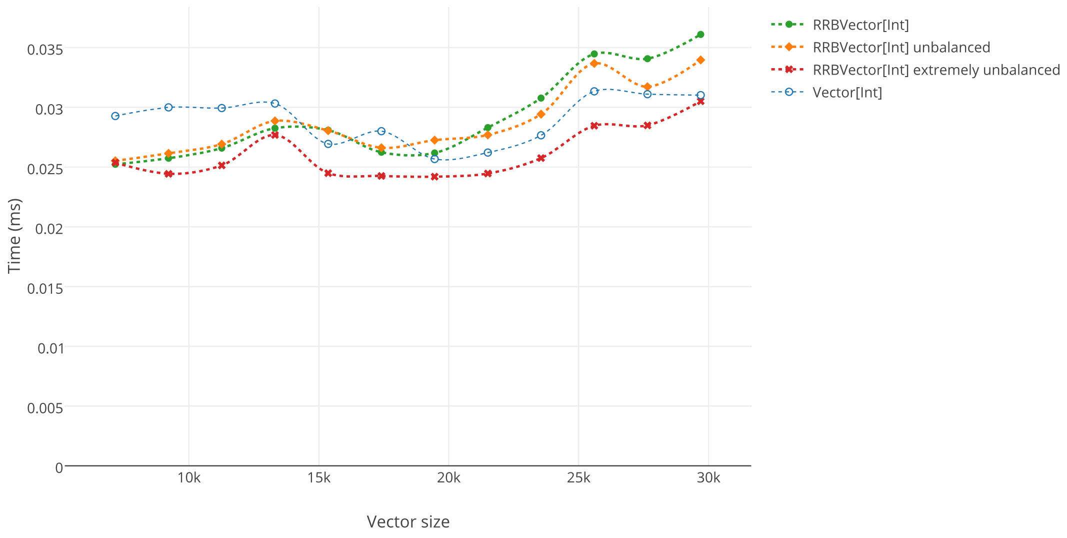
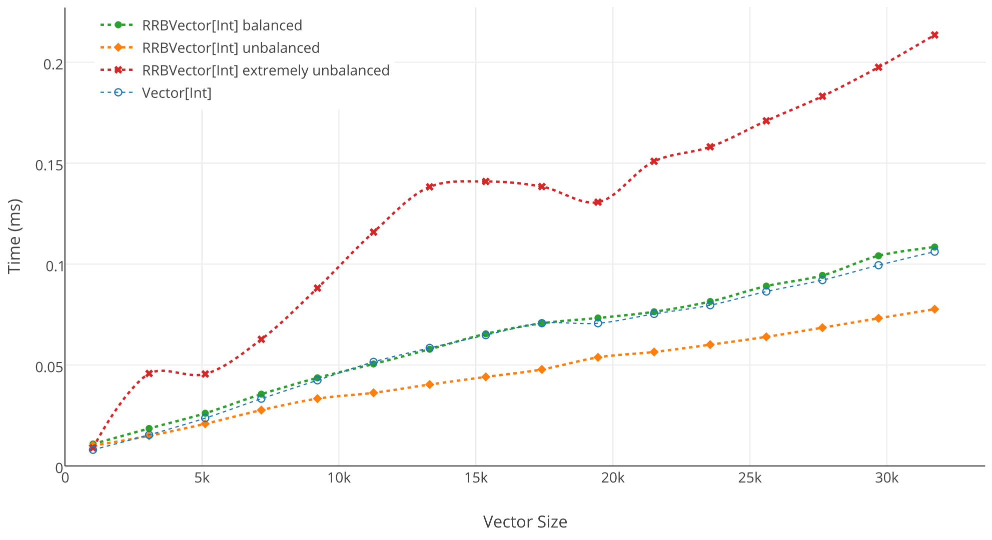


FIGURE 4.6: Time to execute 256 prepend operations. This shows the amortized cost of the prepend operation.



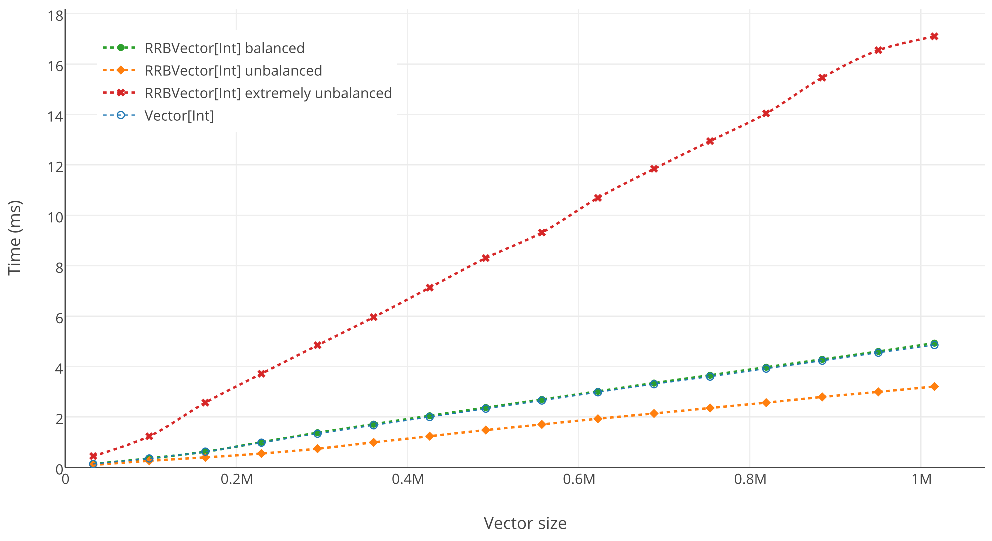


Figure 4.7: Excecution time to iterate through all the elements of the vector.

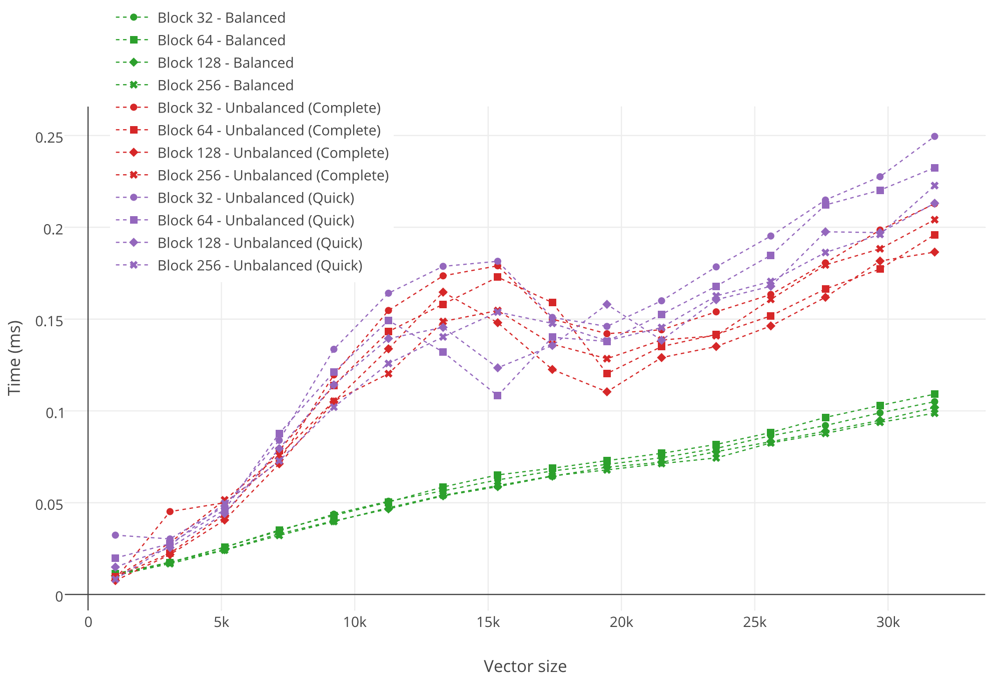
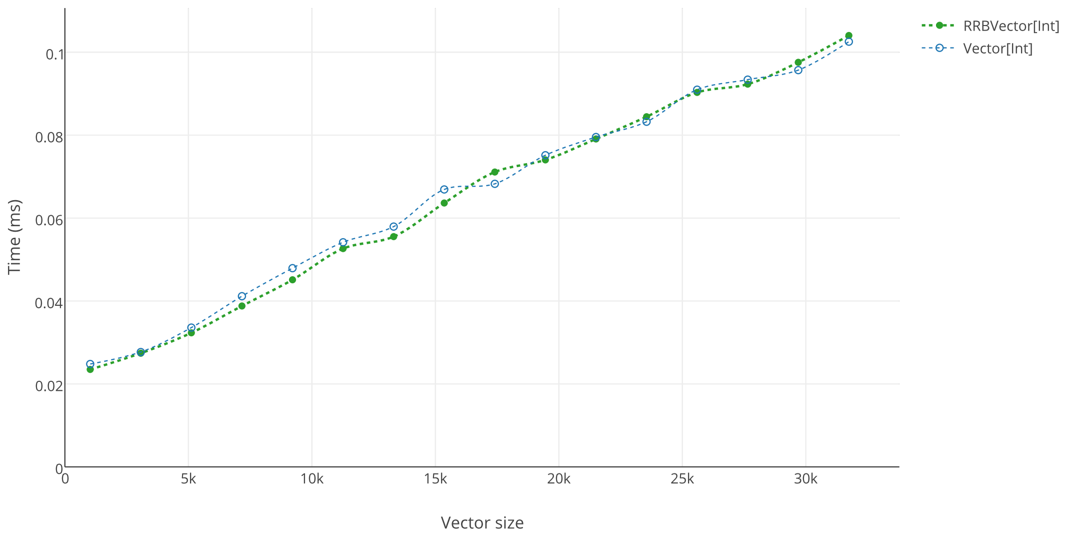


FIGURE 4.8: Excecution time to iterate through all the elements of the vector. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Copmlete/Quick).



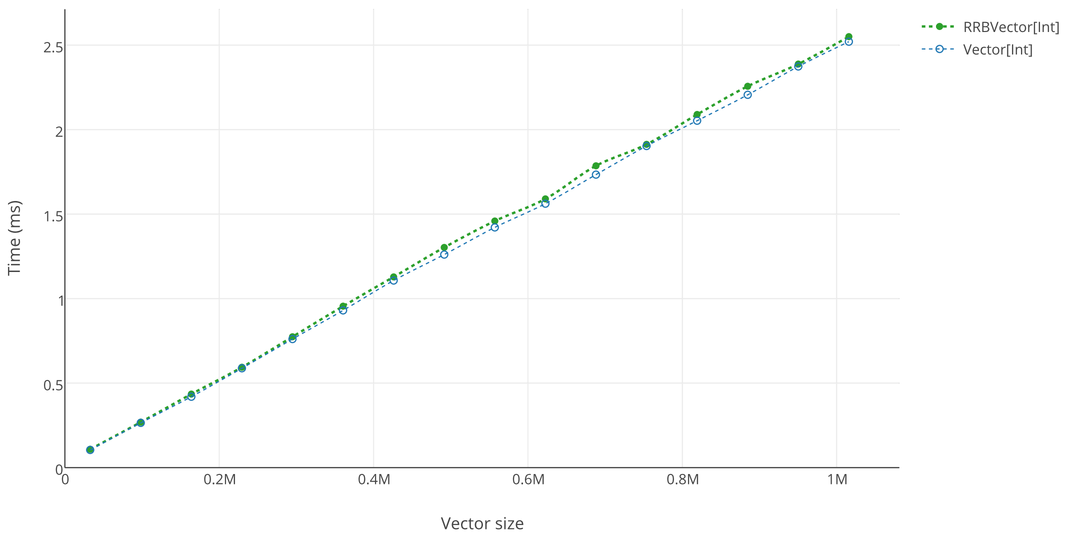


FIGURE 4.9: Execution time to build a vector of a given size.

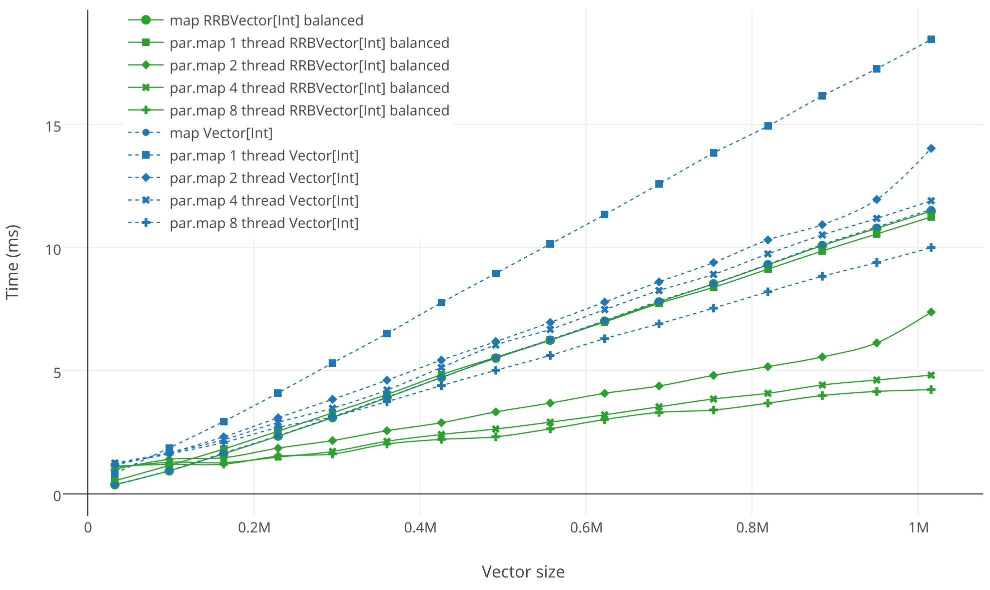


FIGURE 4.10: Benchmark on map and parallel map using the function (x=>x) to show the difference time used in the framework. This time represents the time spent in the splitters and combiners of the parallel collection (iterator and builder for the sequential version).

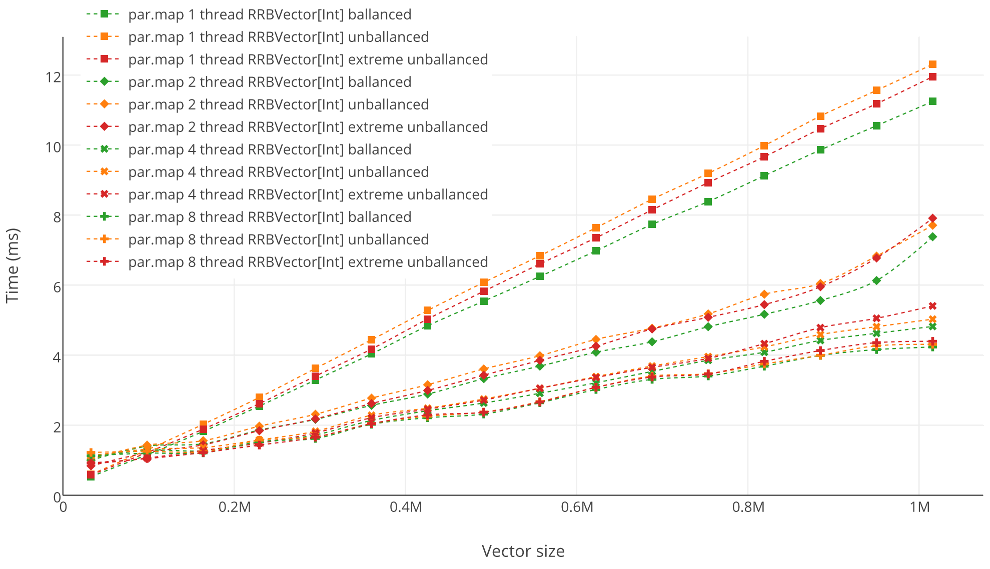


FIGURE 4.11: Benchmark on map and parallel map using the function (x=>x) to show the difference time used in the framework. This time represents the time spent in the splitters and combiners of the parallel collection.

Chapter 5

Testing

5.1 Teststing correctness

5.1.1 Invariant Assertions

5.1.2 Unit tests

5.2 Main Section 2

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Chapter 6

Related Work

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Chapter 7

Conclusions