

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

MASTER THESIS

Relaxed Radix Balanced Trees as Immutable Vectors Scala

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*A thesis submitted in fulfilment of the requirements
for the degree of Master in Computer Science*

in the

LAMP
Computer Science

December 2014

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

Introduction

1.1 Main Section 1

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

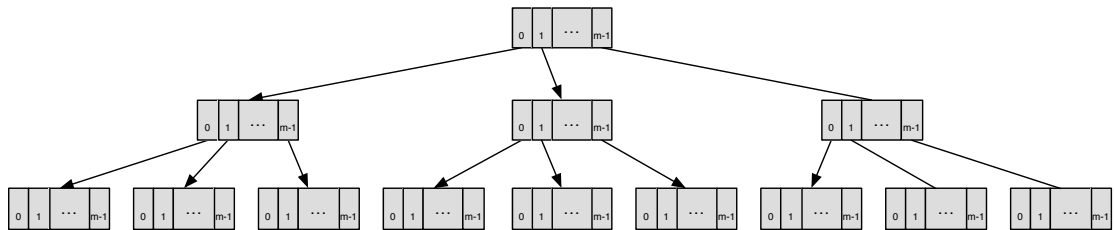


FIGURE 2.1: Radix Balanced Tree Structure

2.1.2 Operations

2.1.2.1 Apply (get element at index)

2.1.2.2 Updated

2.1.2.3 Additions

Append and Prepend

Concatenation and Insert

2.1.2.4 Splits

2.2 Parallel Vectors

2.2.1 Splitter Iterator

2.2.2 Combiner Builder

2.3 Relaxed Radix Balanced Vectors

2.3.1 Tree structure

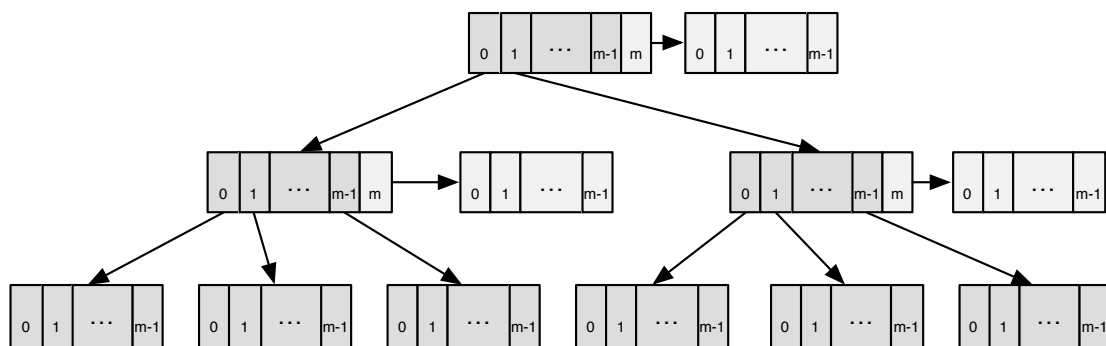


FIGURE 2.2: Radix Balanced Tree

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

I

Chapter 3

Implementation and Optimizations

3.1 Where does time go?

3.1.1 Arrays

3.1.2 Computing indices

$$526843 = \underbrace{00}_{0} \underbrace{000000}_{0} \underbrace{10000}_{16} \underbrace{00010}_{2} \underbrace{01111}_{15} \underbrace{11011}_{27}$$

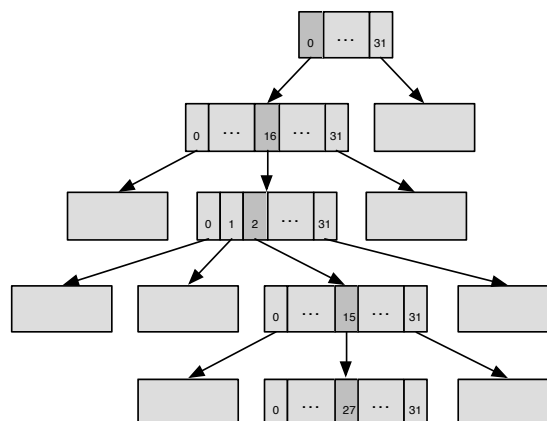


FIGURE 3.1: Accessing element at index 526843 in a tree of depth 5. Empty nodes represent collapses subtrees.

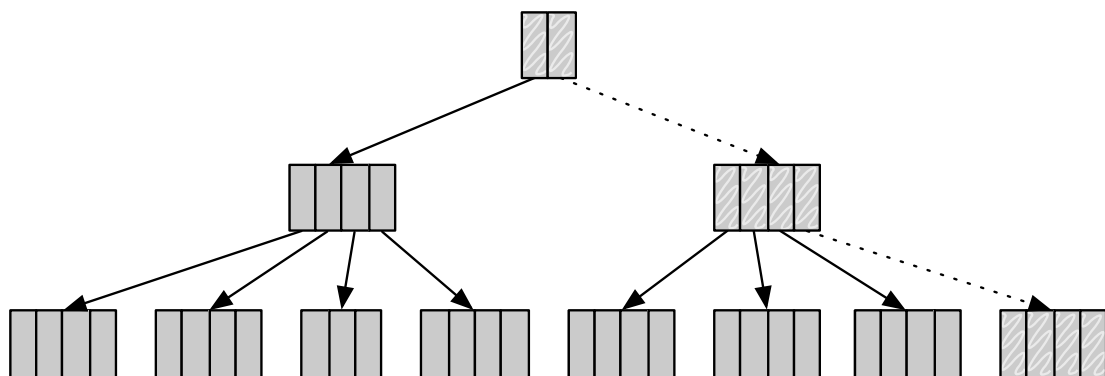
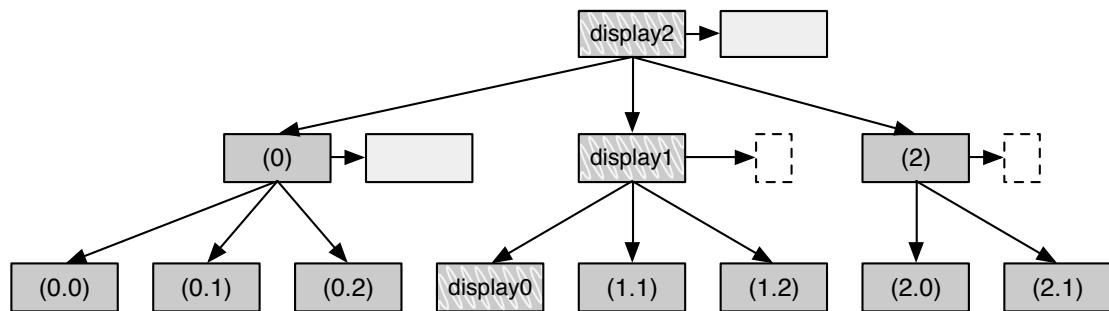


FIGURE 3.3: Radix Balanced Tree Transient state

3.3 Builder

3.4 Iterator

3.5 Relaxing the Radix

3.5.1 Displays

3.5.2 Builder

3.5.3 Iterator

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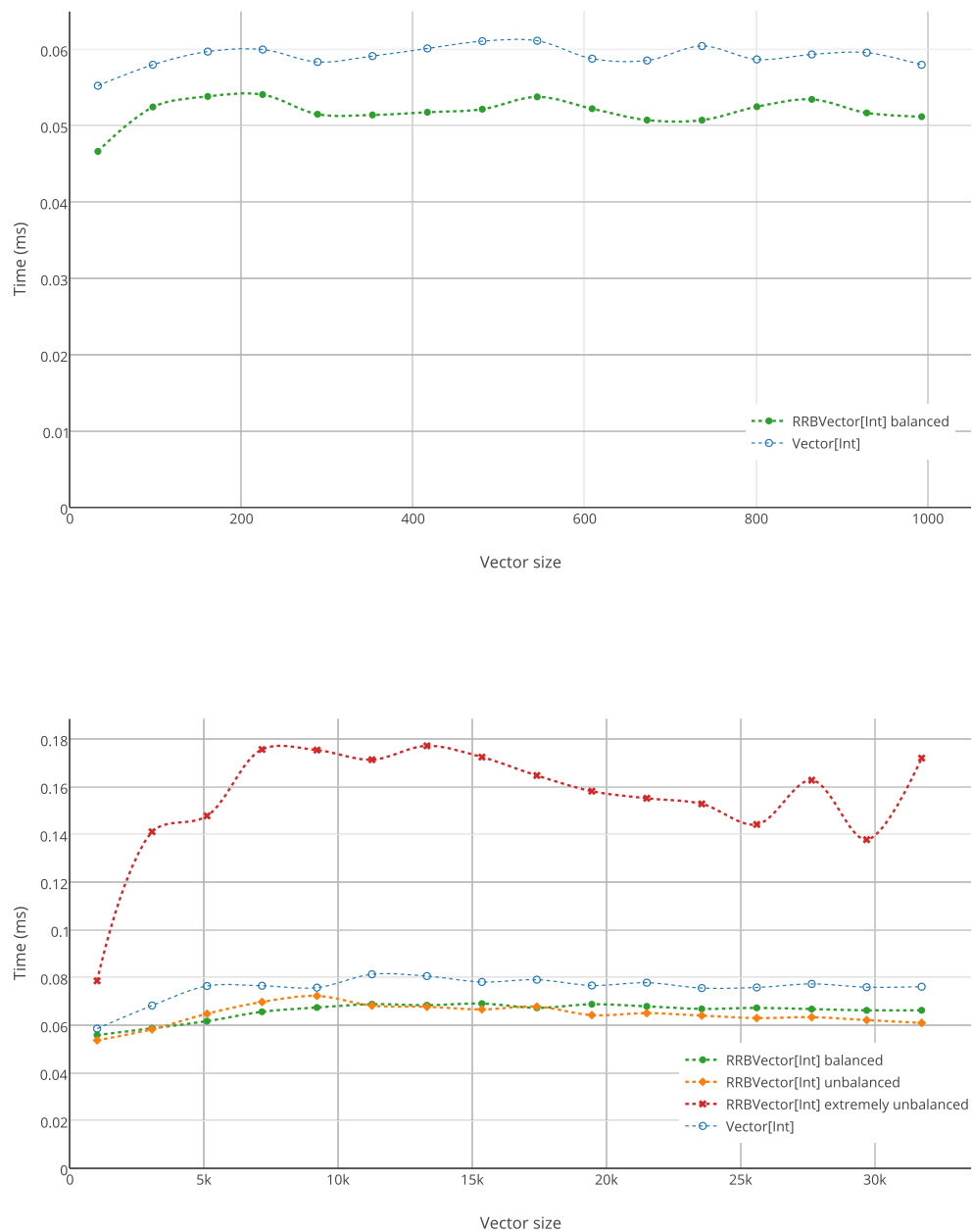


FIGURE 4.1: Time to execute 10k apply operations on sequential indices.

Chapter 4

Performance

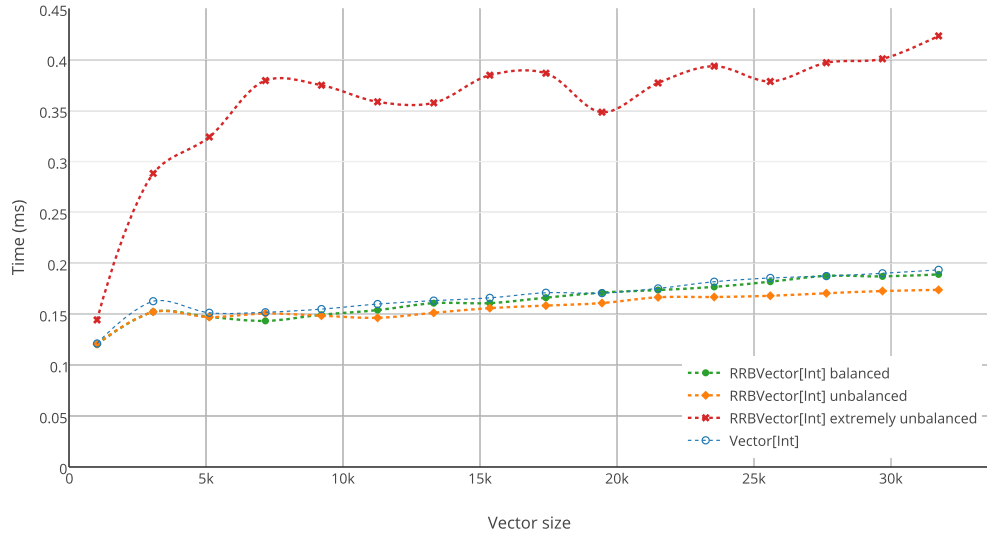


FIGURE 4.2: Time to execute 10k apply operations on random indices.

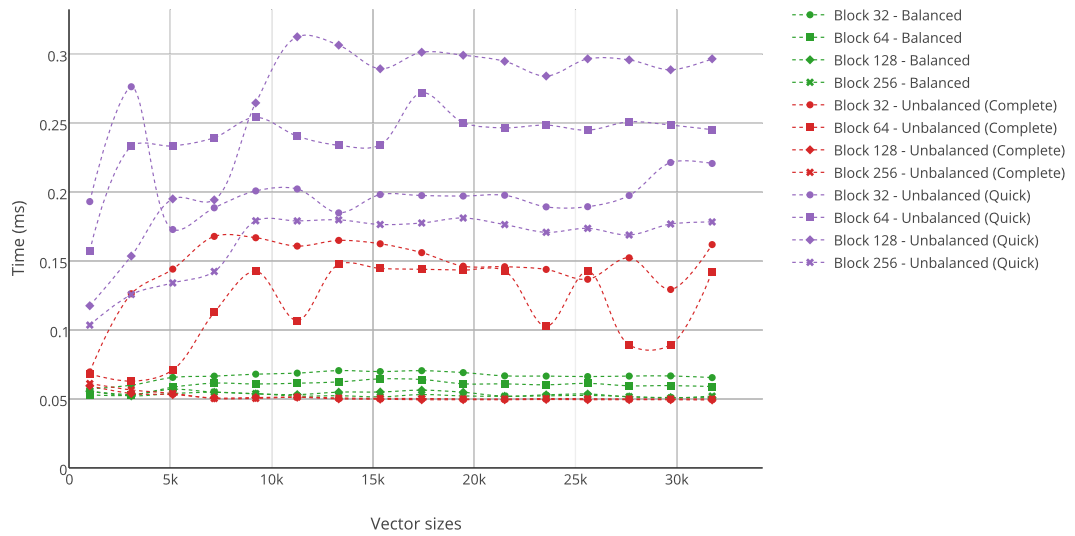


FIGURE 4.3: Time to execute 10k apply operations on sequential indices. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Complete/Quick).

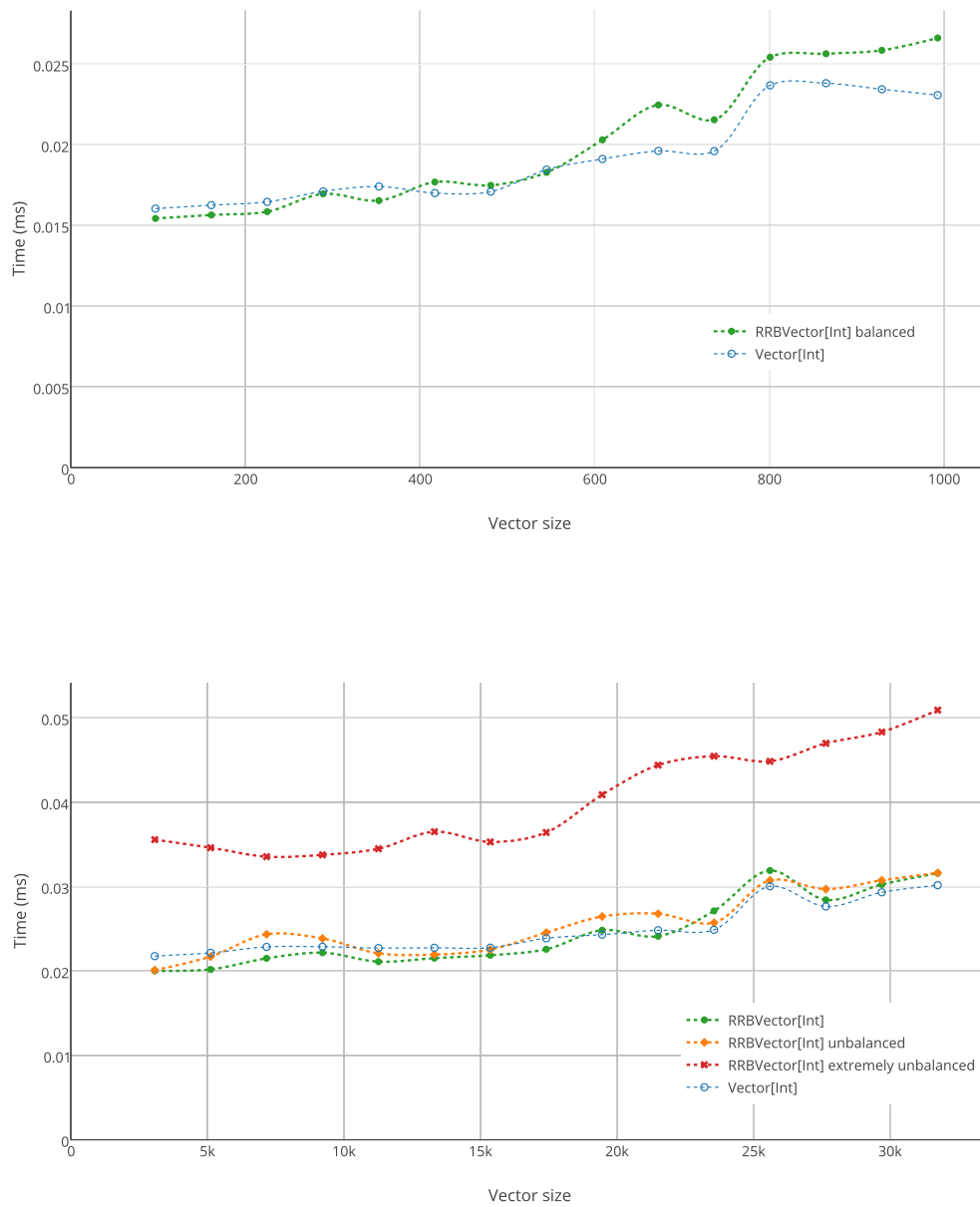


FIGURE 4.4: Time to execute 256 append operations. This shows the amortized cost of the append operation.

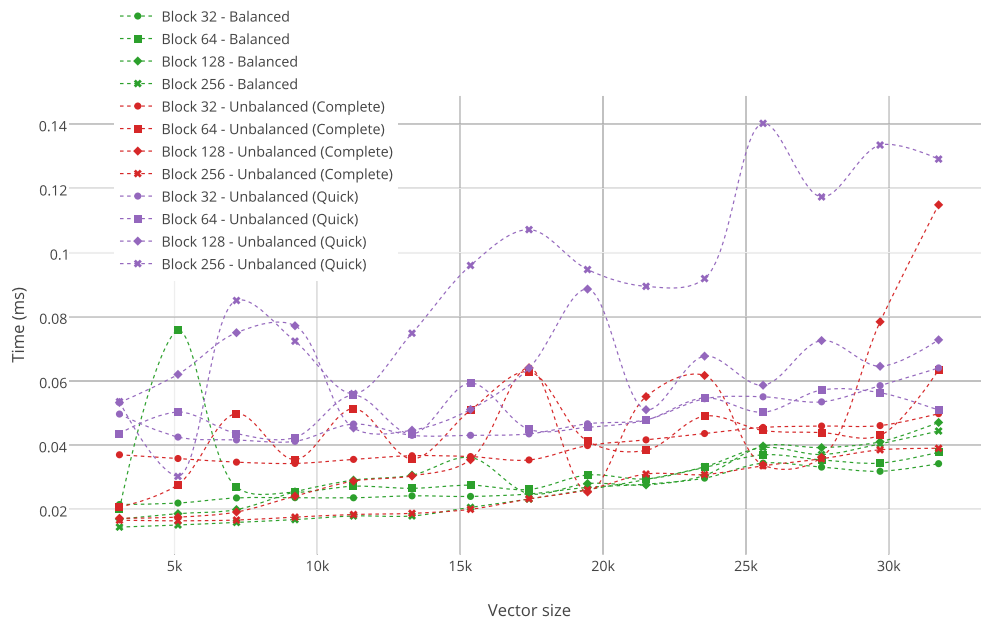


FIGURE 4.5: Time to execute 256 append operations. This shows the amortized cost of the append operation. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Complete/Quick).

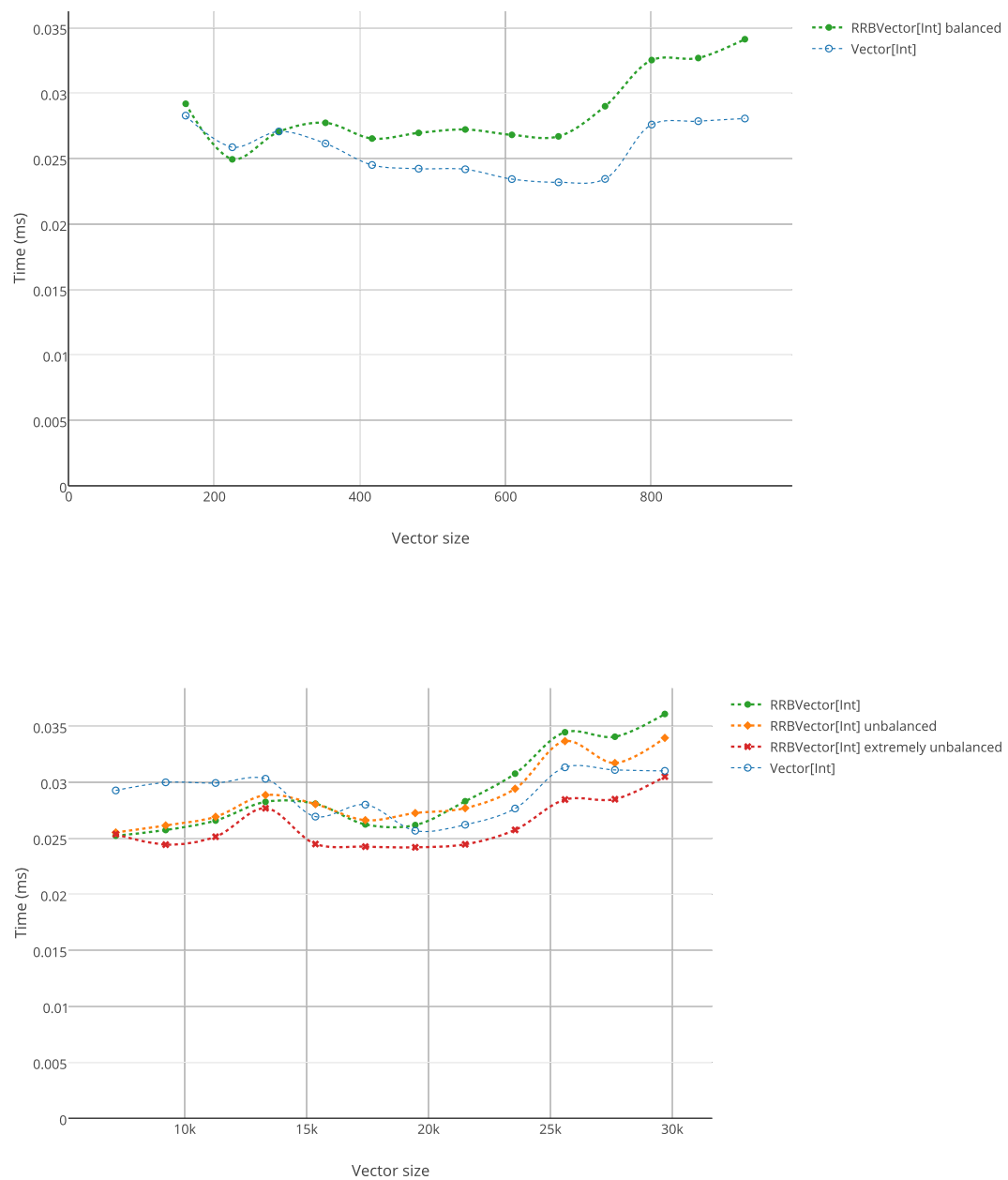


FIGURE 4.6: Time to execute 256 prepend operations. This shows the amortized cost of the prepend operation.

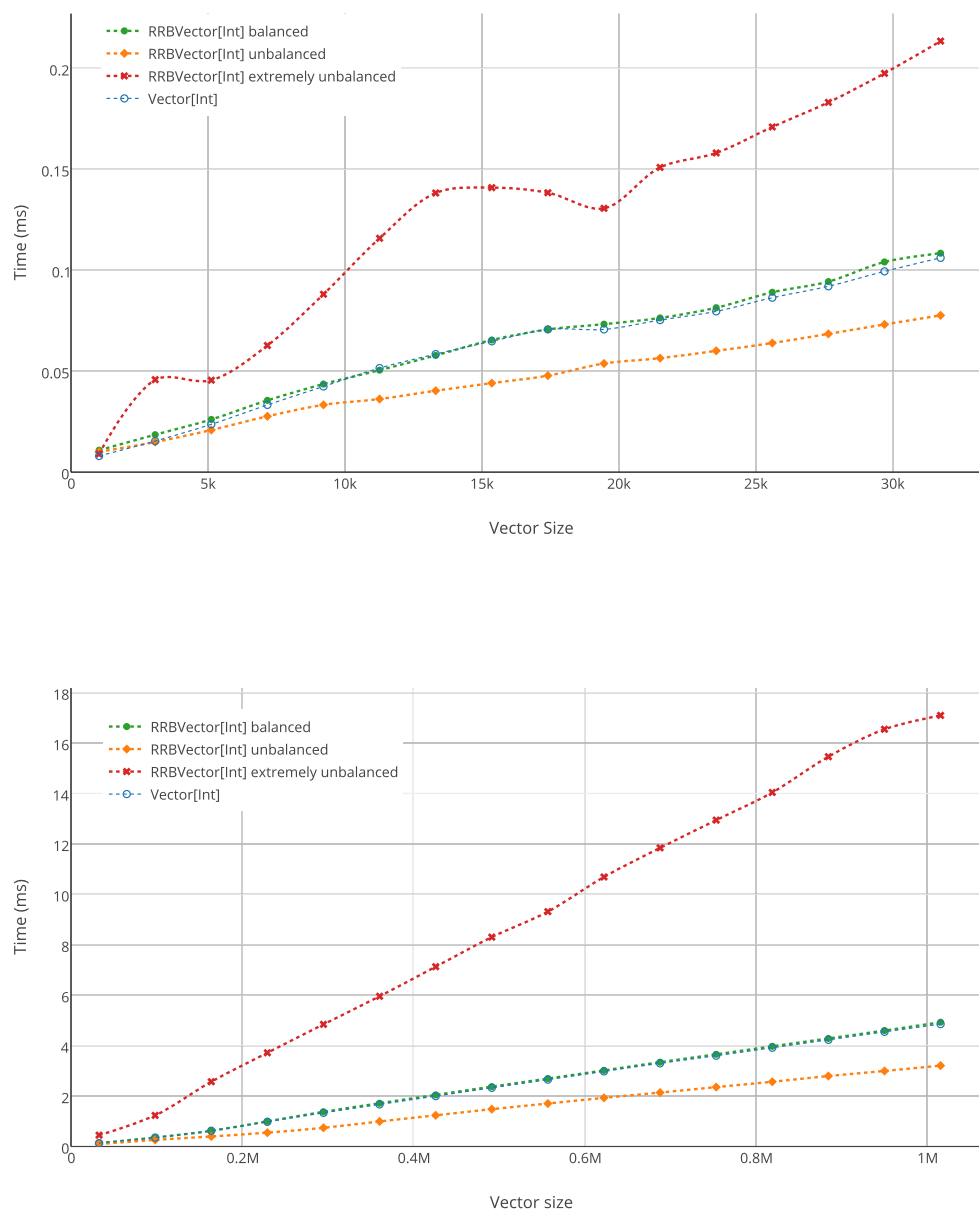


FIGURE 4.7: Execution time to iterate through all the elements of the vector.

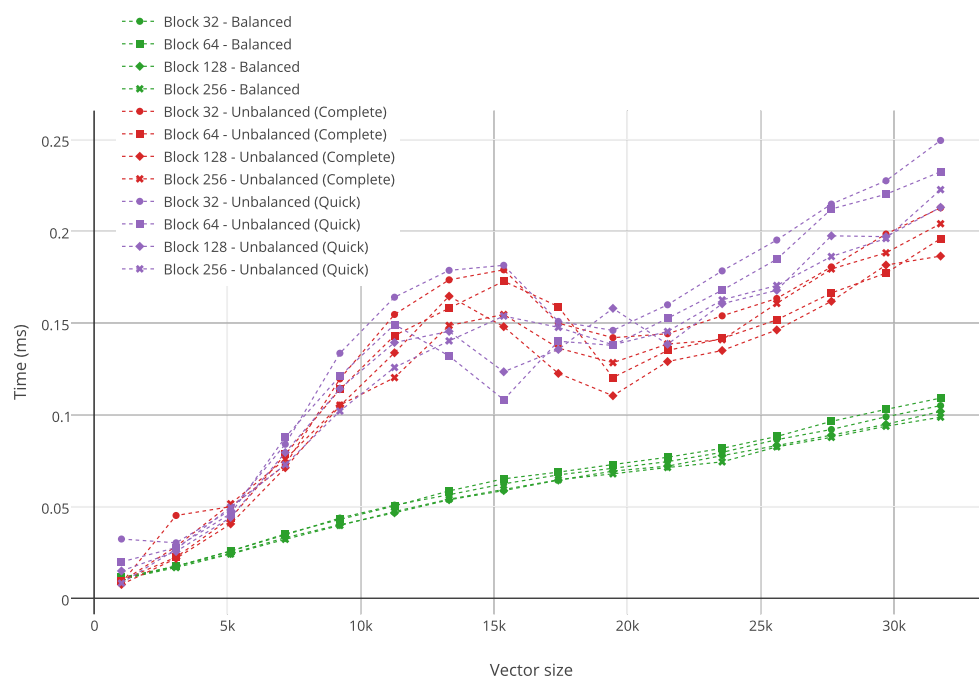


FIGURE 4.8: Execution time to iterate through all the elements of the vector. Comparing performances for different block sizes and different implementation of the concatenation inner branch rebalancing (Complete/Quick).

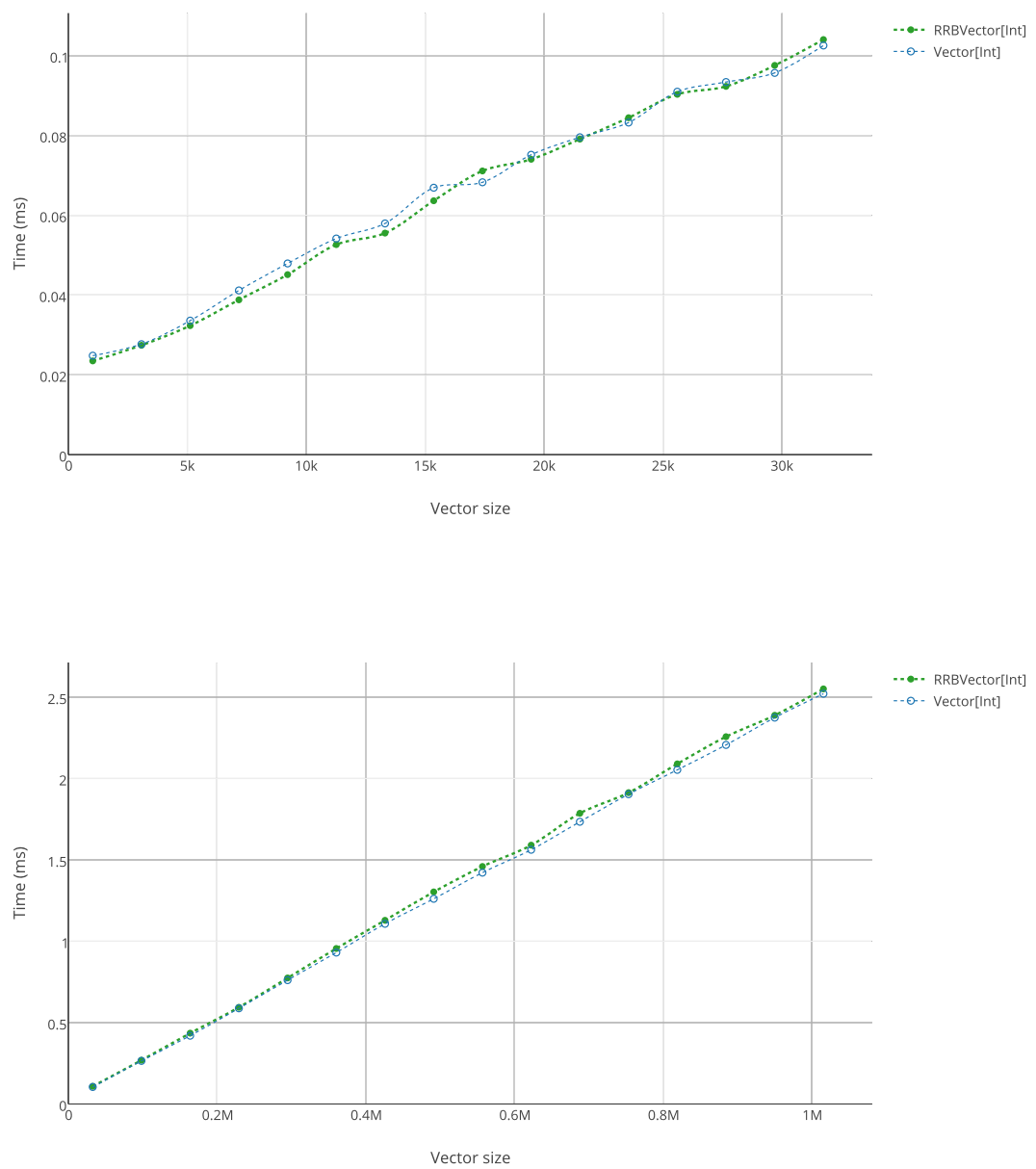


FIGURE 4.9: Execution time to build a vector of a given size.

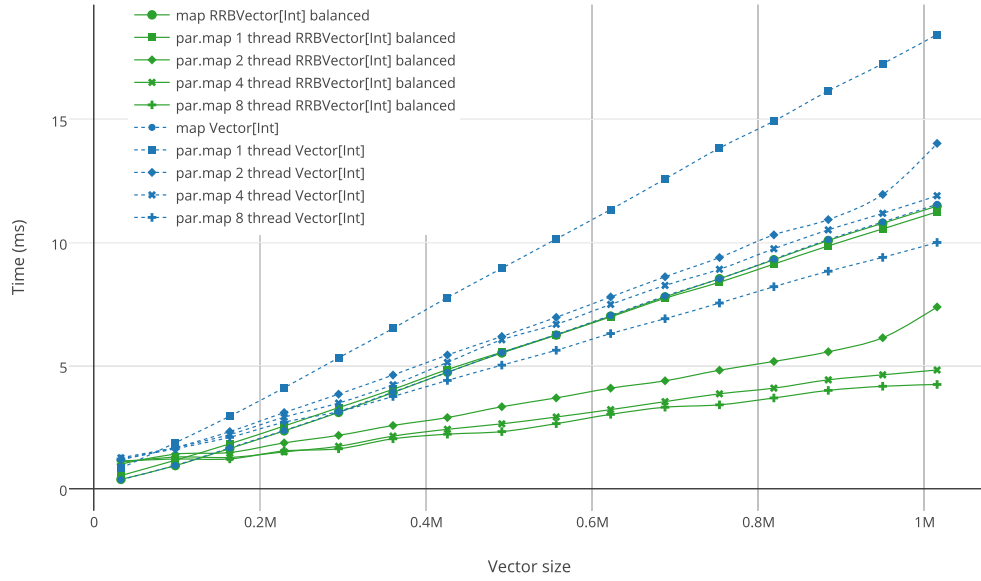


FIGURE 4.10: Benchmark on map and parallel map using the function $(x \Rightarrow x)$ to show the difference time used in the framework. This time represents the time spent in the splitters and combiners of the parallel collection (iterator and builder for the sequential version).

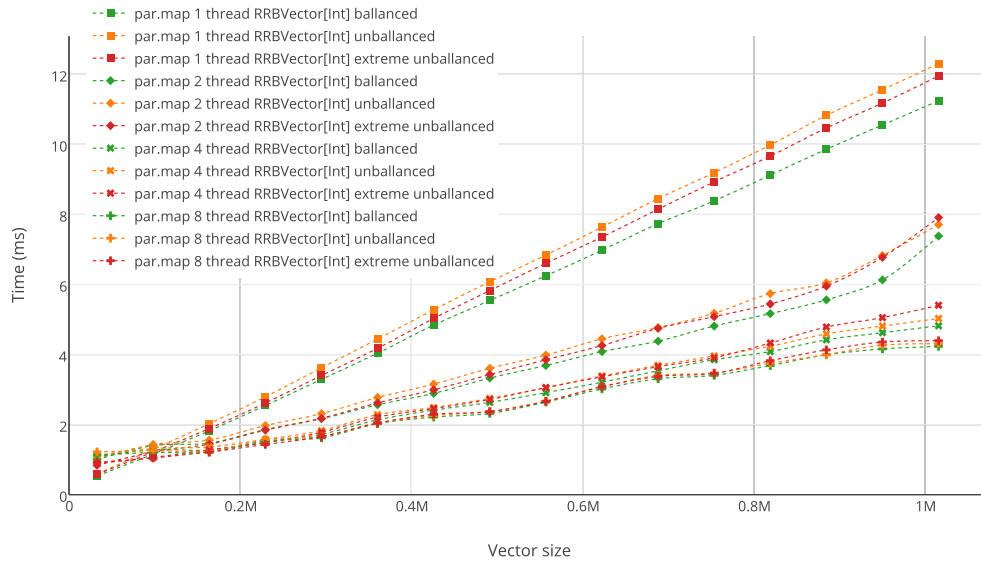


FIGURE 4.11: Benchmark on map and parallel map using the function $(x \Rightarrow x)$ to show the difference time used in the framework. This time represents the time spent in the splitters and combiners of the parallel collection.

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

6.1 RRB-Vectors in Clojure

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Chapter 7

Conclusions