



**Mahidol University**  
International College

**ICCS315 Applied Algorithms**  
Assignment 1 Report

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# Chapter 1

## Resizable Arrays

Traditionally, resizable array has a high amortized cost depending on  $\alpha$  for expansion and shrinking. HAT array theoretically fares with a constant amortized cost on expansion and shrinking. Our goal is to perform the benchmarking of the actual implementation of traditionally resizable array and Sitarski's HAT array.

### 1.1 Set up

Both of data structure implementations are written in C++ which runs on ubuntu server. The actual implement is in [Github](#).

### 1.2 Append latency

In this section, the cost of appending one key to the array mainly comes from reading memory. On traditional resizable array, pushing new key to the back costs approximately 47 cycles from reading memory pointer which needs to be conducted at most the entire array. On the other hand, Sitarski's HAT array takes less cycle per append operation which is 26 cycles since the entire array is separated into  $b$  size where  $b$  where  $b = 2^k$ .

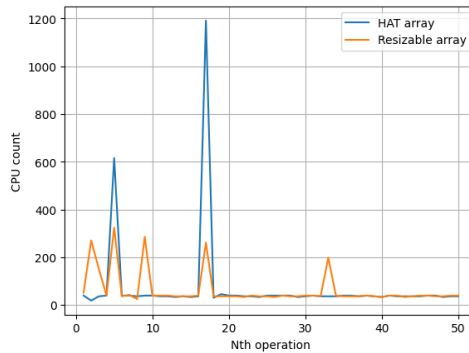


Figure 1.1: Benchmark of each append costs

Figure 1.1 shows the cost of each append out of 50 append operations. Traditional

resizable array shows up to stike CPU cycle more on each operation since the expansion happens more often than HAT array. However, HAT array costs significantly higher cycle because the resizing needs to be done in both levels combine with copying data over.

In conclusion, traditional resizable array takes more cycle to access memory and append new day than HAT array. On the expansion, tradditional resizable array is better than HAT array.

### 1.3 Overall throughput

In section 1.1, I have shown append latency which conclude to have different benefits. For this benchmark, I will test inserting 50 elements to both tradditional resizable array and HAT array. As a consequence, resizable array takes 1153 cycles on average while HAT array takes 1114 cycles on average. Even though the expansion is costly in HAT array, overall throughput of it is around 5 percents faster than resizable array.

# Chapter 2

## Skip lists

# Chapter 3

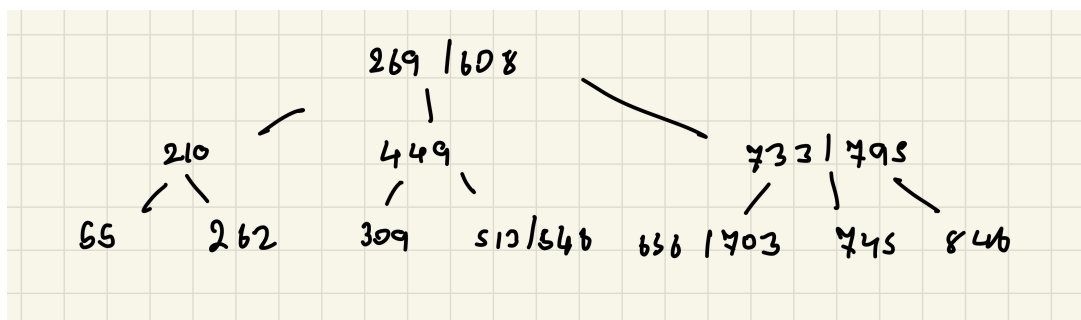
## (a,b) tree

### 3.1 Multiple keys insertion.

Starting with an empty tree, we want to insert the following keys:

733, 703, 608, 846, 309, 269, 55, 745, 548, 449, 513, 210, 795, 656, 262

The result of  $(2,3)$  tree is



### 3.2 Key deletion

Suppose that we want to delete 309 in  $(2,3)$  tree, it falls into case 1 which we need to steal from sibling.

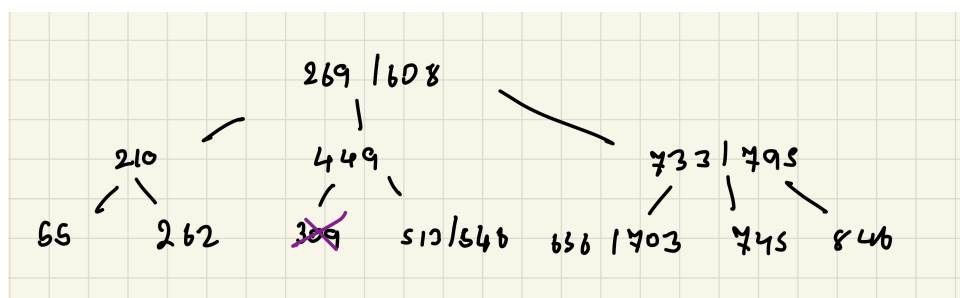


Figure 3.1: Unbalanced tree without key 309

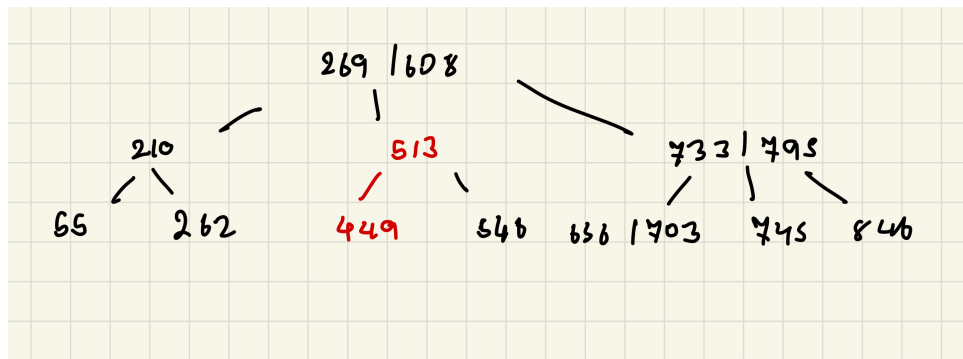


Figure 3.2: Balanced tree after finding replacement by stealing

As you can see in Figure 3.2, the replacements are 513 and 449 which 513 is the new parent node that has 449 and 548 as a child nodes.

$$\alpha_{me} = a - 1 + 1$$

# Chapter 4

## B-tree speed