Hellacious Homebrewed Hashing

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Table of Contents

01

The Assignment

What are we doing?

02

The Problem

What are we solving?

03

My Solution

What did I come up with?

04

The Results

How does it fare?

01

The Assignment

Hash Tables

- The assignment is to create a custom implementation of Python’s dictionary.
- A dictionary stores data in “key, value” pairs, where a given key is used to retrieve a value.
- In the background, the hash of the given key decides in what position the key, value pair is placed.
- Because the hash table knows that the exact hash will always be in that position, it has a retrieval time of O(1).

02

The Problem

Resizing

- One problem with hash tables is what to do when they get full.
- The simple method is to make another, bigger hash table and simply rehash all the items in the bigger table.
- However, this leads to performance concerns, as every item must be rehashed individually and added to the new table the moment the old one gets full.

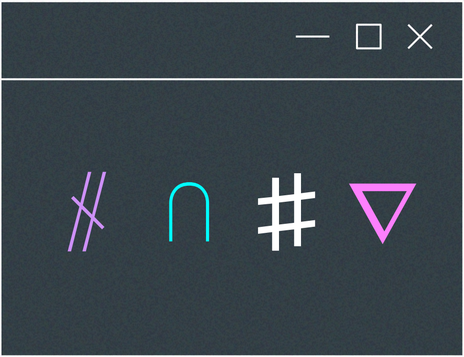
03

The Solution

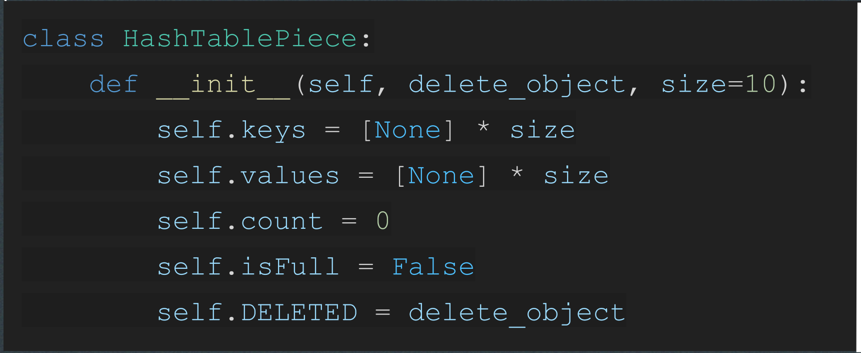
Incremental Resizing

- The other solution is to spread out the item transfer across multiple operations.
- Instead of transferring all at once, the table transfers an item from the smaller table to the bigger one every time a new item is added to the table.
- Once the smaller table is empty, it is replaced with the bigger table, and the cycle continues.
- Once the new table is full, a newer, bigger, better one is created, and the same per operation transfer is used to move everything across.

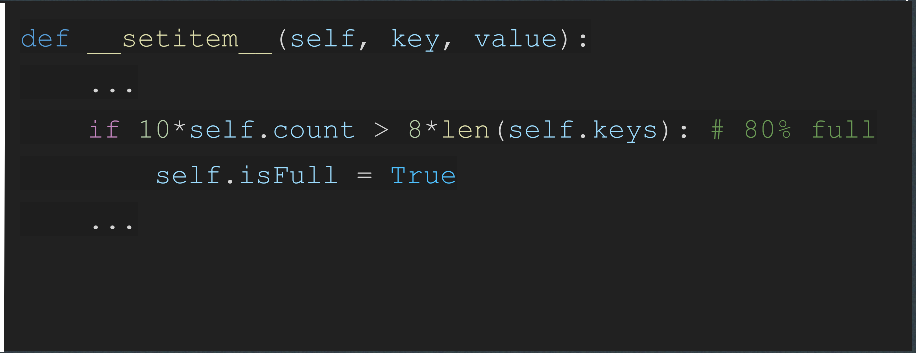
My Implementation



- My implementation uses reduced versions of hash tables.
- Each one is exactly the same as a regular hash table, except that:
  - it does not resize itself
  - it stores a whether or not it has reached capacity (defined as 80% full)
  - it takes in an object to use as a placeholder when an item is deleted instead of defining its own object.



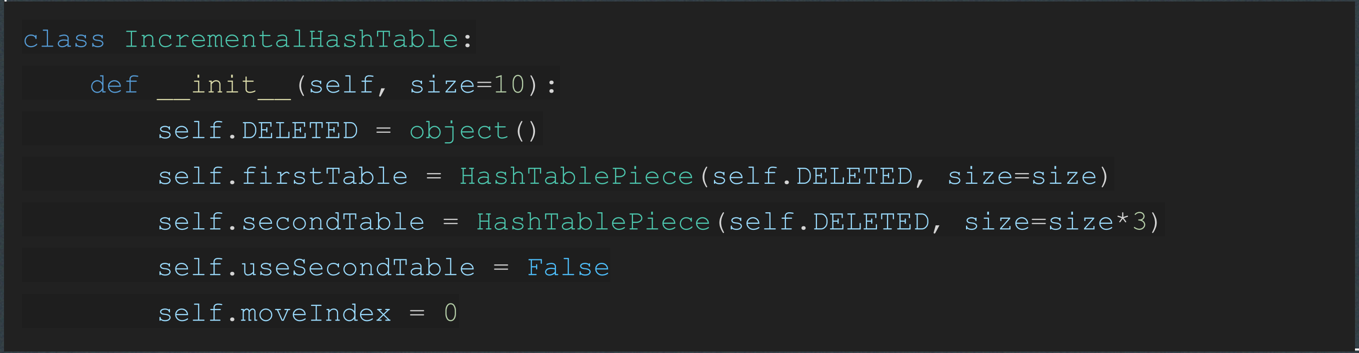
```python
class HashTablePiece:
    def __init__(self, delete_object, size=10):
        self.keys = [None] * size
        self.values = [None] * size
        self.count = 0
        self.isFull = False
        self.DELETED = delete_object
```



```python
def __setitem__(self, key, value):
    ...
    if 10*self.count > 8*len(self.keys): # 80% full
        self.isFull = True
    ...
```

Structure

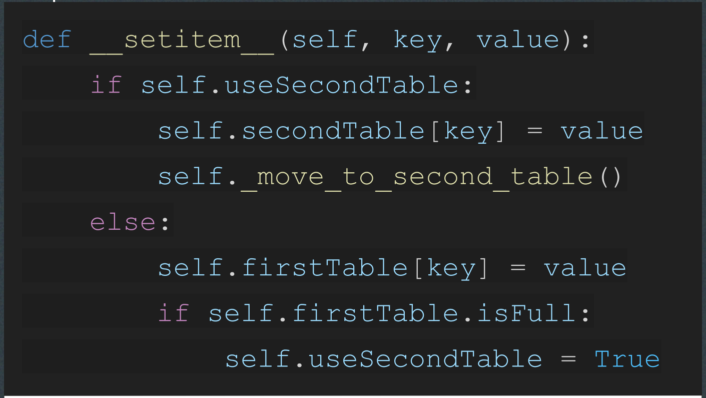
- The master table class contains two of the “reduced” hash tables, as well as a common deleted placeholder object to pass onto the two tables.
    - One of them is three times the size as the other.
- The master table manages the smaller ones and handles switching between the two tables and moving items across them.



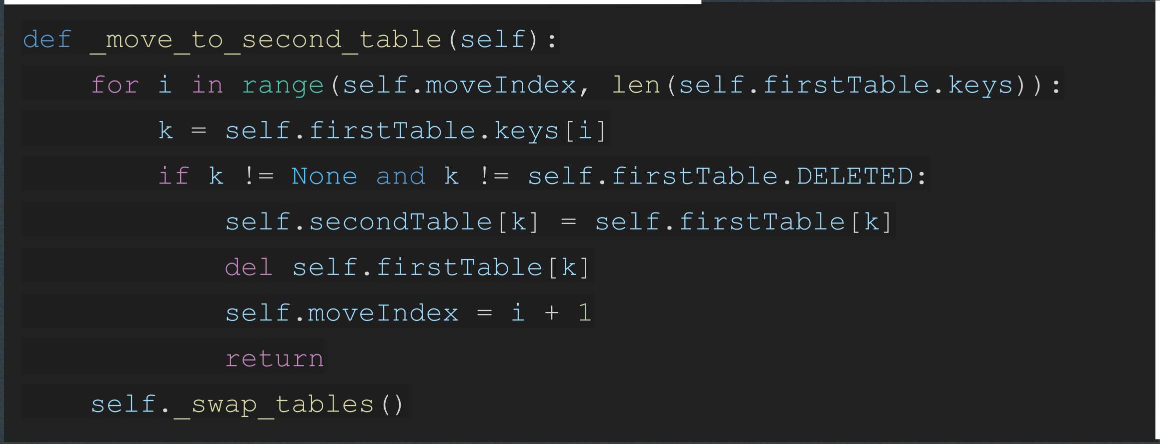
```
class IncrementalHashTable:
    def __init__(self, size=10):
        self.DELETED = object()
        self.firstTable = HashTablePiece(self.DELETED, size=size)
        self.secondTable = HashTablePiece(self.DELETED, size=size*3)
        self.useSecondTable = False
        self.moveIndex = 0
```

Transferring

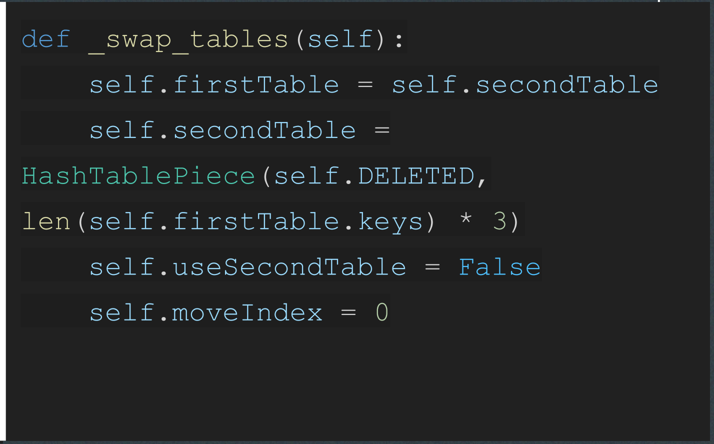
- When items are added to the master table, it stores them in the smaller first table.
- Once it marks itself full, the master table switches to the second table.
  - Then, items are moved over from top to bottom of the first table every time an item is added to the master table (which goes to the second table).



```
def __setitem__(self, key, value):
    if self.useSecondTable:
        self.secondTable[key] = value
        self._move_to_second_table()
    else:
        self.firstTable[key] = value
        if self.firstTable.isFull:
            self.useSecondTable = True
```



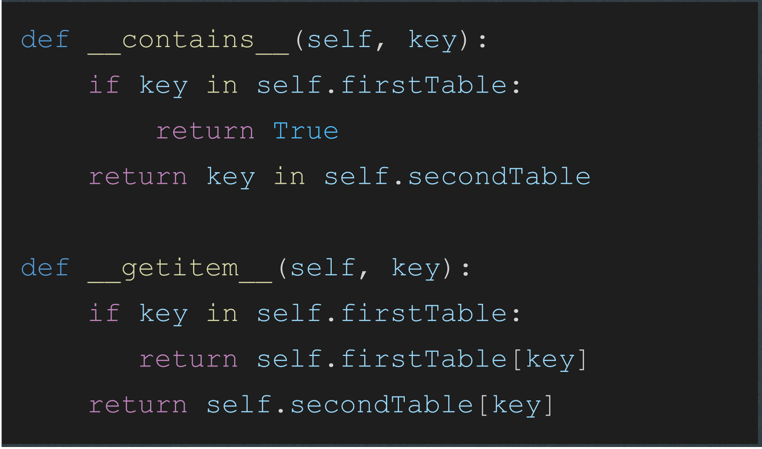
```
def _move_to_second_table(self):
    for i in range(self.moveIndex, len(self.firstTable.keys)):
        k = self.firstTable.keys[i]
        if k != None and k != self.firstTable.DELETED:
            self.secondTable[k] = self.firstTable[k]
            del self.firstTable[k]
            self.moveIndex = i + 1
            return
    self._swap_tables()
```



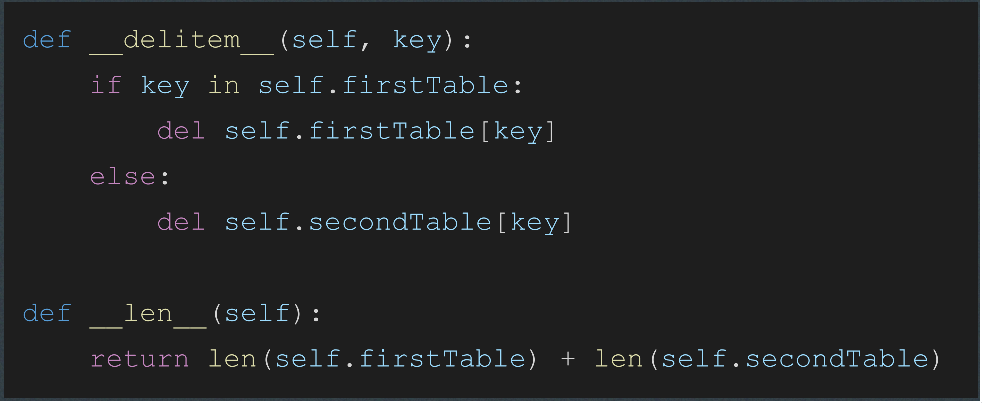
```
def _swap_tables(self):
    self.firstTable = self.secondTable
    self.secondTable =
HashTablePiece(self.DELETED,
len(self.firstTable.keys) * 3)
    self.useSecondTable = False
    self.moveIndex = 0
```

Other Features

- All other features of a hash table were implemented
    - set, contains, get, del, len, str
- The master table handles going between both tables for each function.



```python
def __contains__(self, key):
    if key in self.firstTable:
        return True
    return key in self.secondTable

def __getitem__(self, key):
    if key in self.firstTable:
        return self.firstTable[key]
    return self.secondTable[key]
```

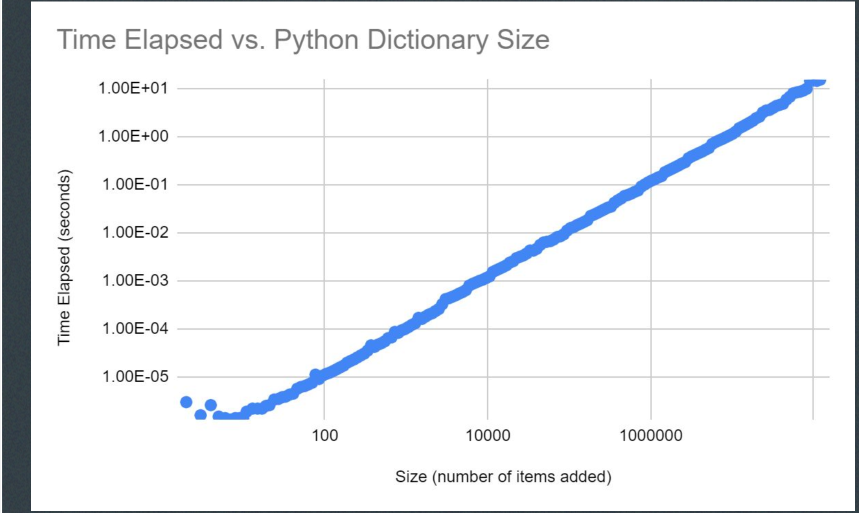


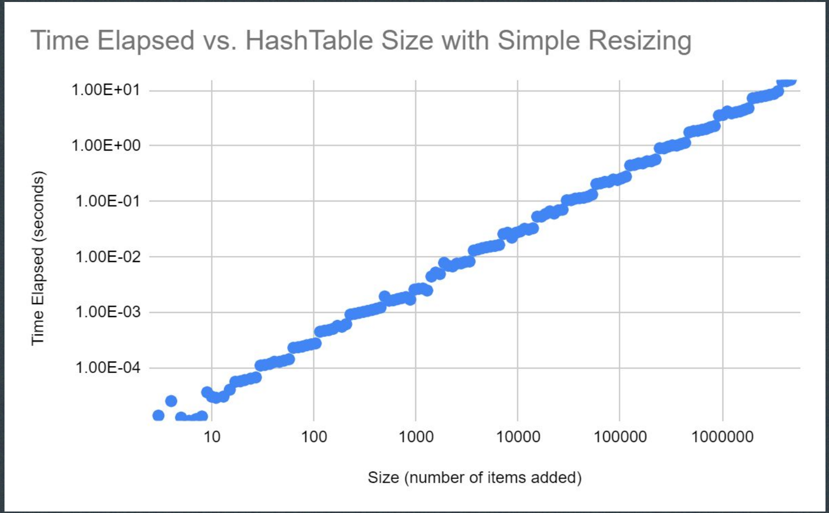
```python
def __delitem__(self, key):
    if key in self.firstTable:
        del self.firstTable[key]
    else:
        del self.secondTable[key]

def __len__(self):
    return len(self.firstTable) + len(self.secondTable)
```

04

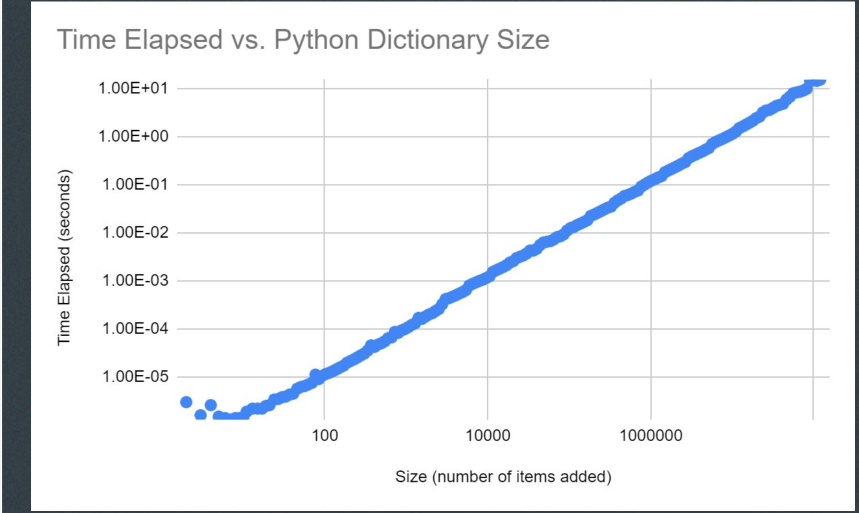
The Results

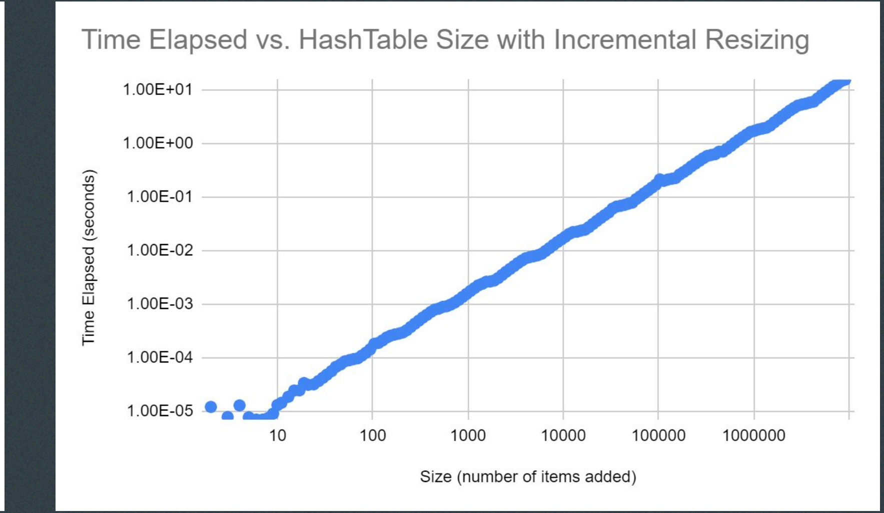
Dictionary vs. Simple Resizing



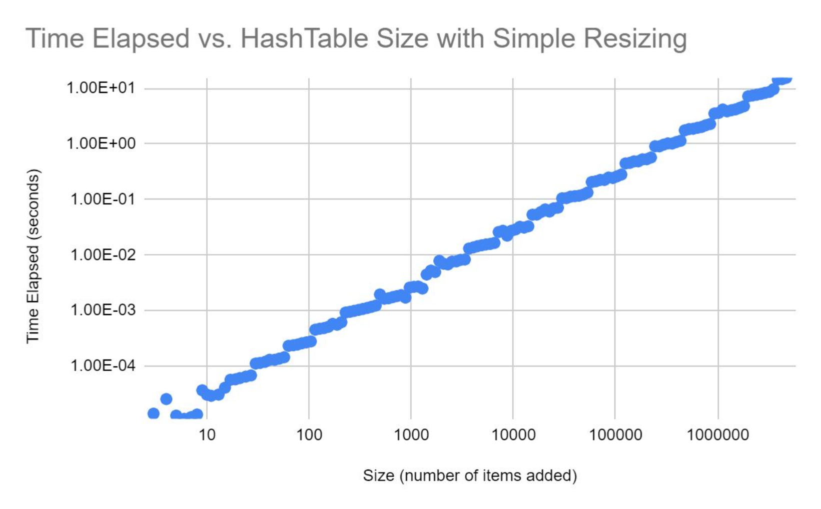


Dictionary vs. Incremental Resizing

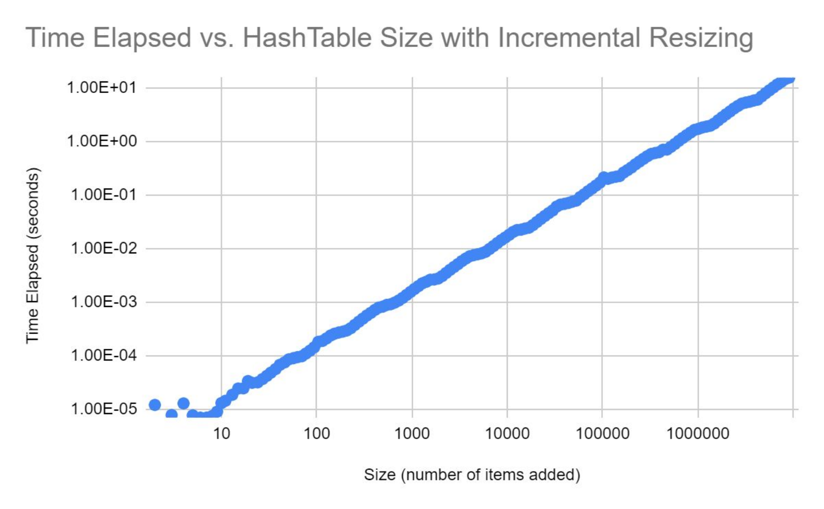




Simple vs. Incremental Resizing



Time Elapsed vs. HashTable Size with Simple Resizing



Time Elapsed vs. HashTable Size with Incremental Resizing

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