

<codedaily/>

Data Structure
& Algorithms 101
with doodles

🐱 girliemac 🐦 @girlie_mac



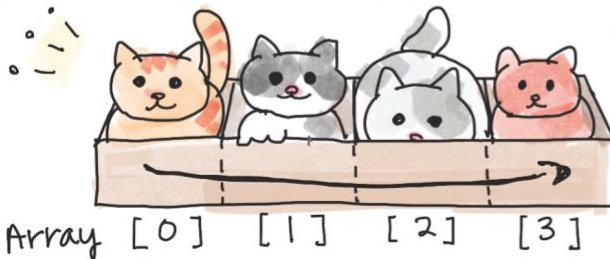
Data Structures

Array & Linked List

Array a linear data structure, stored in contiguous memory locations.

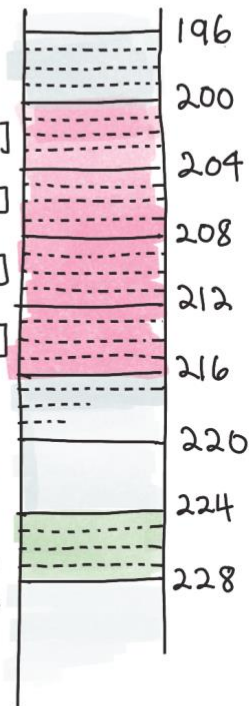


Address 200 204 208 212



$a[0]$
 $a[1]$
 $a[2]$
 $a[3]$

- ♥ Assume each 🐱 is an integer
= requires 4 bytes space
- ♥ The array of 🐱 must be allocated contiguously!
→ address 200 — 216



🎉 yay!

- ♥ Can randomly access w/ index
 $a[2] \rightarrow$ 🐱
- ♥ Contiguous = no extra memory allocated = no memory overflow

👎 meh!

- 💡 fixed size. Large space may not be avail for big array
∴ 🐱 took the space! ∴
- 💡 Insert & delete elements are costly.
→ may need to create a new copy of the array & allocate at a new address.

Big O Notation

Time complexity of an algorithm

"How much time it takes to run a function as the size of the input grows."

Runtime

Const

array1 = [



array

number of elements

n=5

Let's see if there is a needle in the haystack!

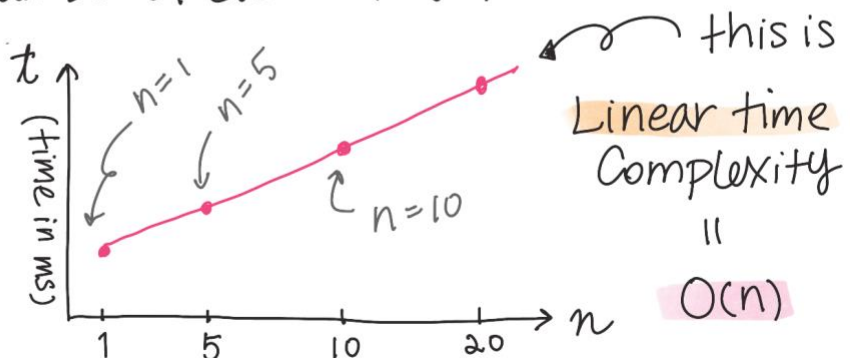
JS

```
Const numNeedles = (haystack, needle) => {  
  let count = 0  
  for (let i = 0; haystack.length; i++) {  
    if (haystack[i] === needle) count += 1;  
  }  
  return count;  
}
```



How long does it take to execute when the number of elements (n) is:

♥ execution time grows linearly as array size increases!



@girnie_mac

@girlie-mac

Big O Notation

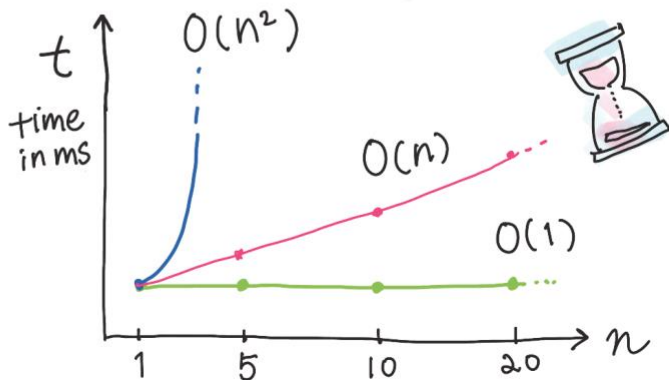
JS Let's see if we have some function that doesn't actually loop the array:

```
const alwaysTrueNoMatterWhat = (haystack) => {  
  return true;  
}
```

$n=5$
 $n=10$
 $n=20$
 \vdots

Array size has no effect on the runtime

☆ Constant time
" $O(1)$



☆ Quadratic time = $O(n^2)$

Const

array2 = [🐱, 🌸, 🍰, 🍰, 🍷];

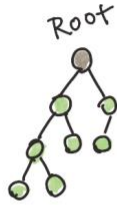
$n=5$, however the runtime is proportional to n^2

```
JS Const hasDuplicates = (arr) => {  
  for (let i=0; i < arr.length; i++)  
    let item = arr[i];  
    if (arr.slice(i+1).indexOf(item) !== -1) {  
      return true;  
    }  
  return false;  
}
```

① Loop thru the array

② Another array lookup w/ indexOf method

Binary Search Tree



Binary tree

tree data structure
each node has at most 2 children

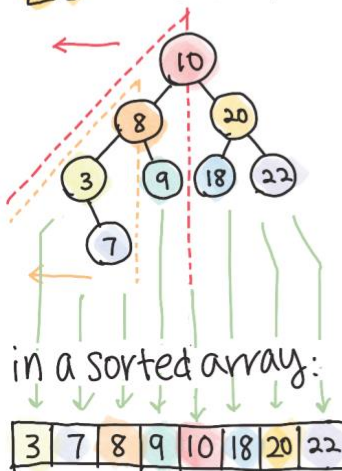
Binary heap

Binary Search Tree

♥ a.k.a. Ordered or sorted binary tree

♥ fast look up
e.g. phone number lookup table by name

👍 Rule of thumb



★ each value of all nodes in the left subtrees is lesser

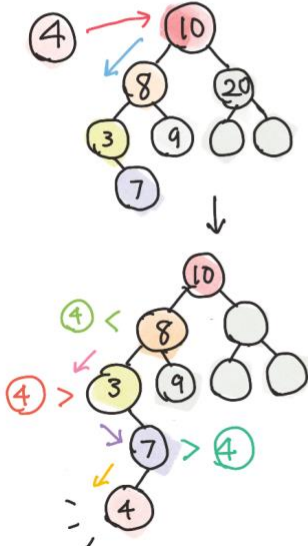
△ 10's left subtrees: 8, 3, 9, 7

△ 8: 3, 7 ← smaller than parent

★ each value of all nodes in the right subtrees is larger

★ no duplicate values

☆ Insertion → Always add to the lowest spot to be a leaf ~~✗~~ No rearrange!



Let's add 4

1. Compare w/ the root first.

2. 4 < 10 so go left.

3. then compare w/ the next, 8

4. 4 < 8 so go left

5. Compare w/ the 3

6. 4 > 3 so go right.

7. Compare w/ the 7

8. 4 < 7, so add to the left! Done.

Complexity:

Ave. $O(\log n)$

Worst. $O(n)$

@girlie_mac

Data Structures

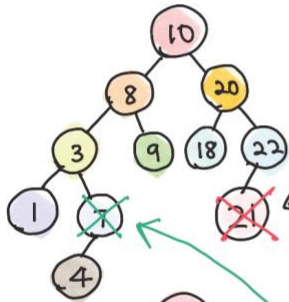
BST

Binary Search Tree!



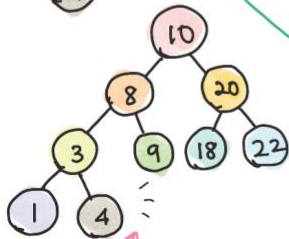
★ Deletion

- Case 1: the to-be-deleted node has no child
- Case 2: the node has 1 child
- Case 3: the node has 2 children



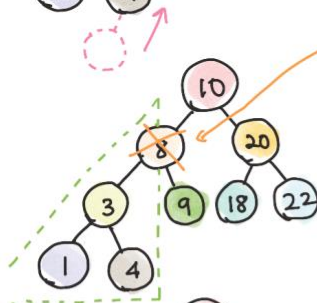
Let's remove (21) ← Case 1.

It has no child, so just remove it from the node. Done! Easy 🍑 peachy!



Now, let's delete (7) ← Case 2

1. just remove it
2. then move the child, (4) to the spot!



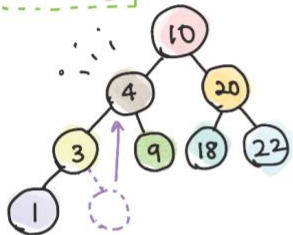
Now, let's delete (8) ← Case 3!

1. Remove it from the spot
2. Then look for the largest node from the left subtree

3. The largest is (4)!

Done! Done!

move the node to the removed spot!
(Alternatively, look for the smallest from the right subtree.)



Complexity:

Ave. $O(\log n)$
Worst. $O(n)$

? (4) originally had no child, but if it has children?

→ Repeat the process!

↳ Find the largest from left subtree, move it

↳ Find the largest from left subtree...

Recursive

Data Structures Hash Table

- ♥ A hash table is used to index large amount of data
- ♥ Quick key-value look up. $O(1)$ on average
 - ↳ Faster than brute-force linear search

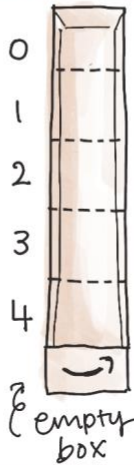
① Let's create an array of size 5.

We're going to add 🐱 data.

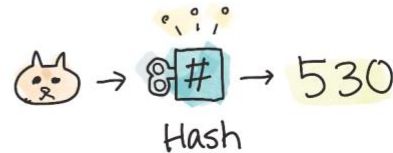
key = "Tabby"

value = "pizza"

Some data
Let's say, favorite food!



② Calculate the hash value by using the key, "Tabby".
e.g. ASCII code, MD5, SHA1



③ Use modulo to pick a position in the array!

🐱 → # → $530 \% 5 = 0$

!!!

[0]



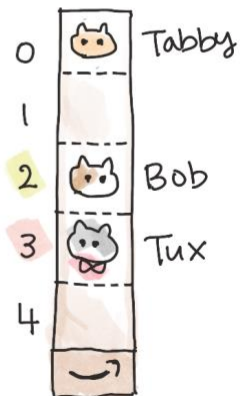
★ The hash is divided by the size of the array.
The remainder is the position!

④ Let's add more data.

🐱 → # → $353 \% 5 = 3$
Tux

🐱 → # → $307 \% 5 = 2$
Bob

Use the same method to add more 🐱



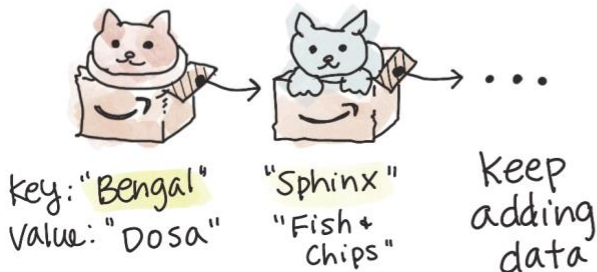
@girlie_mac

★ Collision!

Now we want to add more data.
Let's add "Bengal".

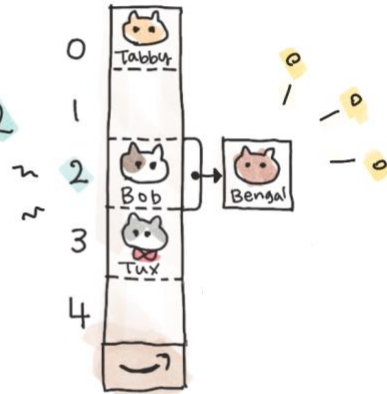
🐱 "Bengal" → 617 → $617 \% 5 = 2$

But [2] slot has been taken by "Bob" already! = collision!
so let's chain Bengal next to Bob! = chaining

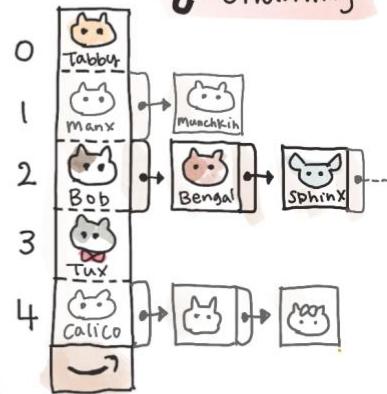


Hash Table

@girlie-mac



chaining



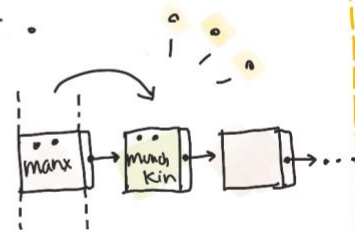
🔍 Searching for data

★ Let's look up the value for "Bob"

- ① Get the hash → 307
- ② Get the index → $307 \% 5 = 2$
- ③ Look up Array [2] → found!

★ Let's look up "munchkin"

- ① Hash → 861
 - ② Index → $861 \% 5 = 1$
 - ③ Array [1] → "manx"
 - ④ Operate a linear-search to find "munchkin"
- ↳ Average $O(n)$



@girlie_mac

Data Structures

Binary Heap



Binary tree

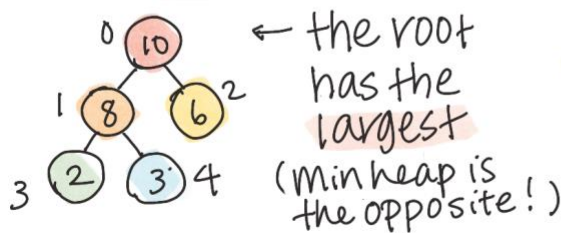
tree data structure
each node has at most 2 children

Binary search tree

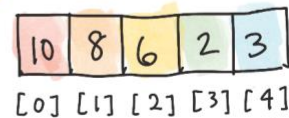
Binary heap

- Complete tree
- Min heap or max heap
- used for priority queue, heap sort etc.

★ Max heap

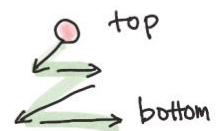


in array



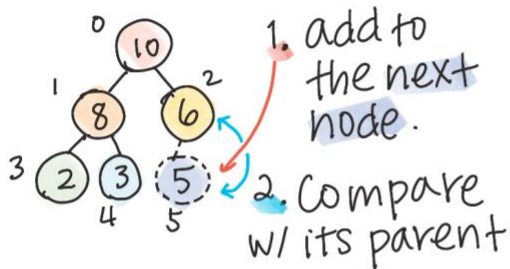
each node has 0 - 2 children

always fill top → bottom, left → right



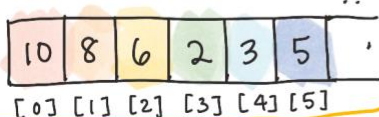
★ Insertion

Let's add 5 to the heap!

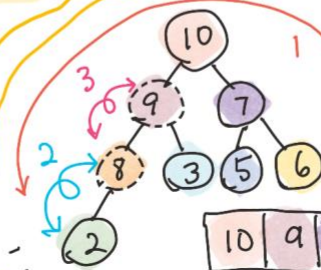
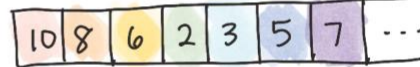


3. the parent is greater.

Cool, it's done!
Let's add more!



Add 7



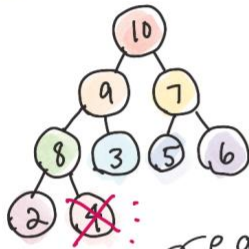
Add to the next node & repeat the process!



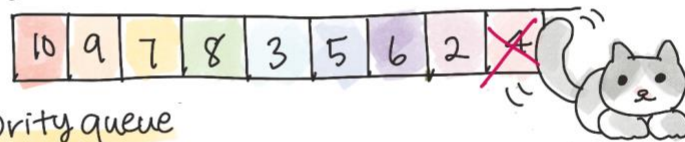
@girlie-mac

Data Structures Binary Heap

★ Heap Deletion

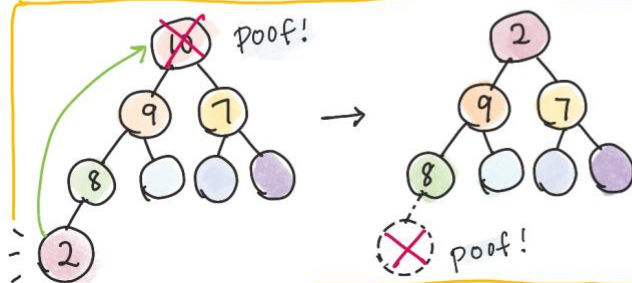


If you want to delete the last leaf, just delete it!

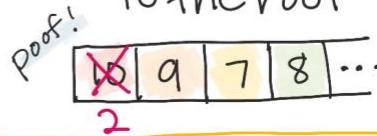


e.g. priority queue

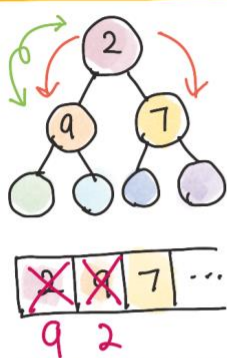
But typically, you would delete root + heapify!



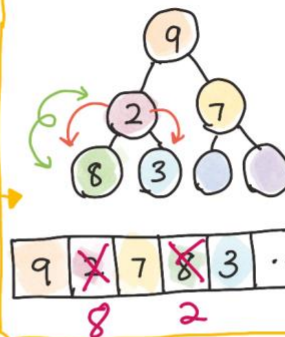
1. Remove the root
2. Move the last leaf to the root



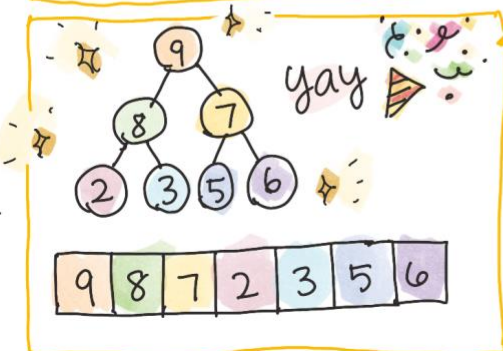
Now, let's place them in the correct order!



If either child is larger than the root, swap it with the larger child.



Repeat. Compare w/ the children + swap w/ the larger child



Time Complexity

- | | Average | Worst |
|----------|-------------|-------------|
| • Insert | $O(1)$ | $O(\log n)$ |
| • Delete | $O(\log n)$ | $O(\log n)$ |



@girlie-mac

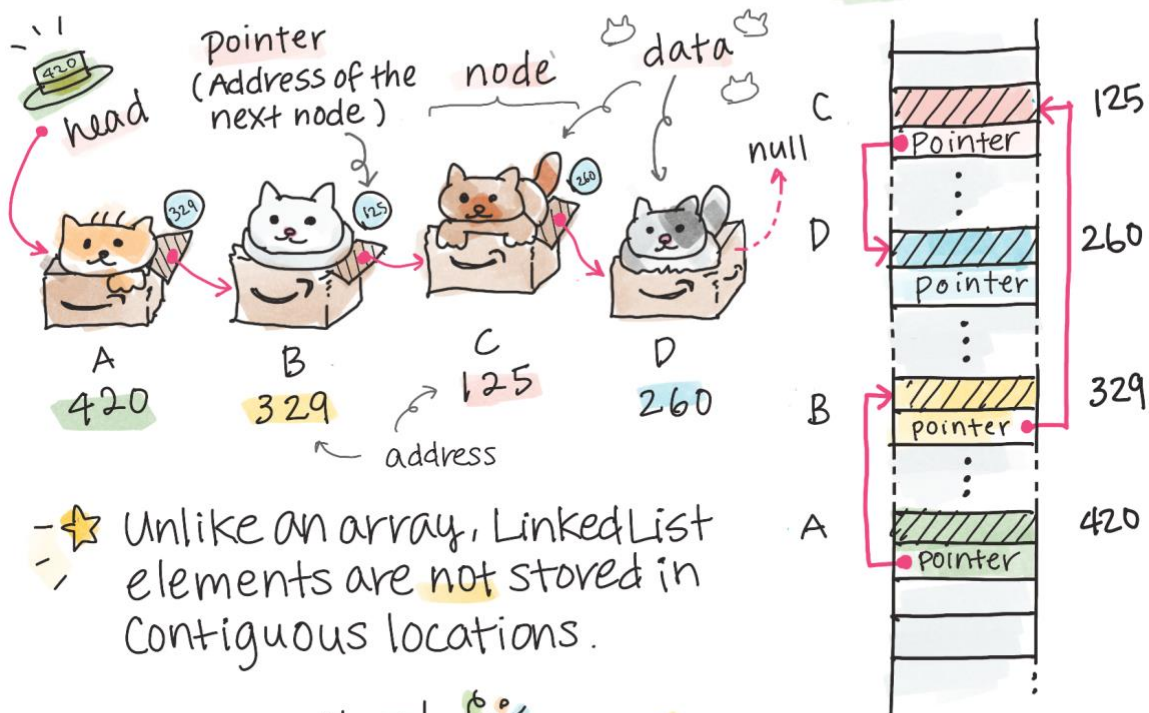
Data Structures

Linked list

Array & Linked List

- ★ a linear data structure
- ★ each element is a separated object & elements are linked w/ pointers

memory



- ★ Unlike an array, LinkedList elements are not stored in contiguous locations.

Yay! 🎉

- ♥ Dynamic data
= size can grow or shrink
- ♥ Insert & delete element are flexible.
→ no need to shift nodes like array insertion
- ♥ memory is allocated at runtime

👎 meh!

- ☠ No random access memory.
→ Need to traverse n times
→ time complexity is $O(n)$. array is $O(1)$
- ☠ Reverse traverse is hard

Data Structures

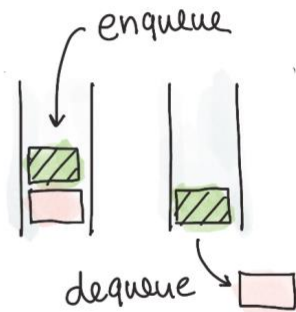
Stack & Queue

LIFO

FIFO

@girlie_mac

A queue is a FIFO (First-in-First-out) data structure, where an element added first (= enqueue) gets removed first (= dequeue)



just like waiting in line at a popular restaurant!



★ Stack as an array in JS

```
let queue = [ ];
```

```
queue.push('Simba'); // ['Simba']
```

```
queue.push('Nyan'); // ['Simba', 'nyan']
```

```
queue.push('maru'); // ['Simba', 'nyan', 'maru']
```

```
let eater = queue.shift(); // eater is 'Simba'
```

♥ Time Complexity should be $O(1)$ for

both enqueue + dequeue but JS `shift()` is slower!

if you `queue.unshift('bad Kitty')`, instead of `push()`, then the cat cuts in to the front of line!

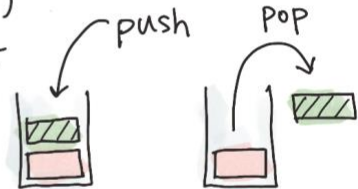
Wrong!

queue is ['nyan', 'maru']

Data Structures

Stack & Queue

A stack is a LIFO (Last-in-First-out) data structure, where an element added last (=push) gets removed first (=pop)



♥ just like a stack of ice cream scoops!



☆ Stack as an array in JS

```
let stack = [ ];
```

```
stack.push('mint choc'); // ['mint choc']
```

```
stack.push('vanilla'); // ['mint choc', 'vanilla']
```

```
stack.push('strawberry'); // ['mint choc', 'vanilla', 'strawberry']
```

```
let eaten = stack.pop(); // eaten is 'strawberry'
```

♥ Time complexity is $O(1)$ for both pop + push.

['mint choc', 'vanilla']

omg, the bottom one is always melting !!