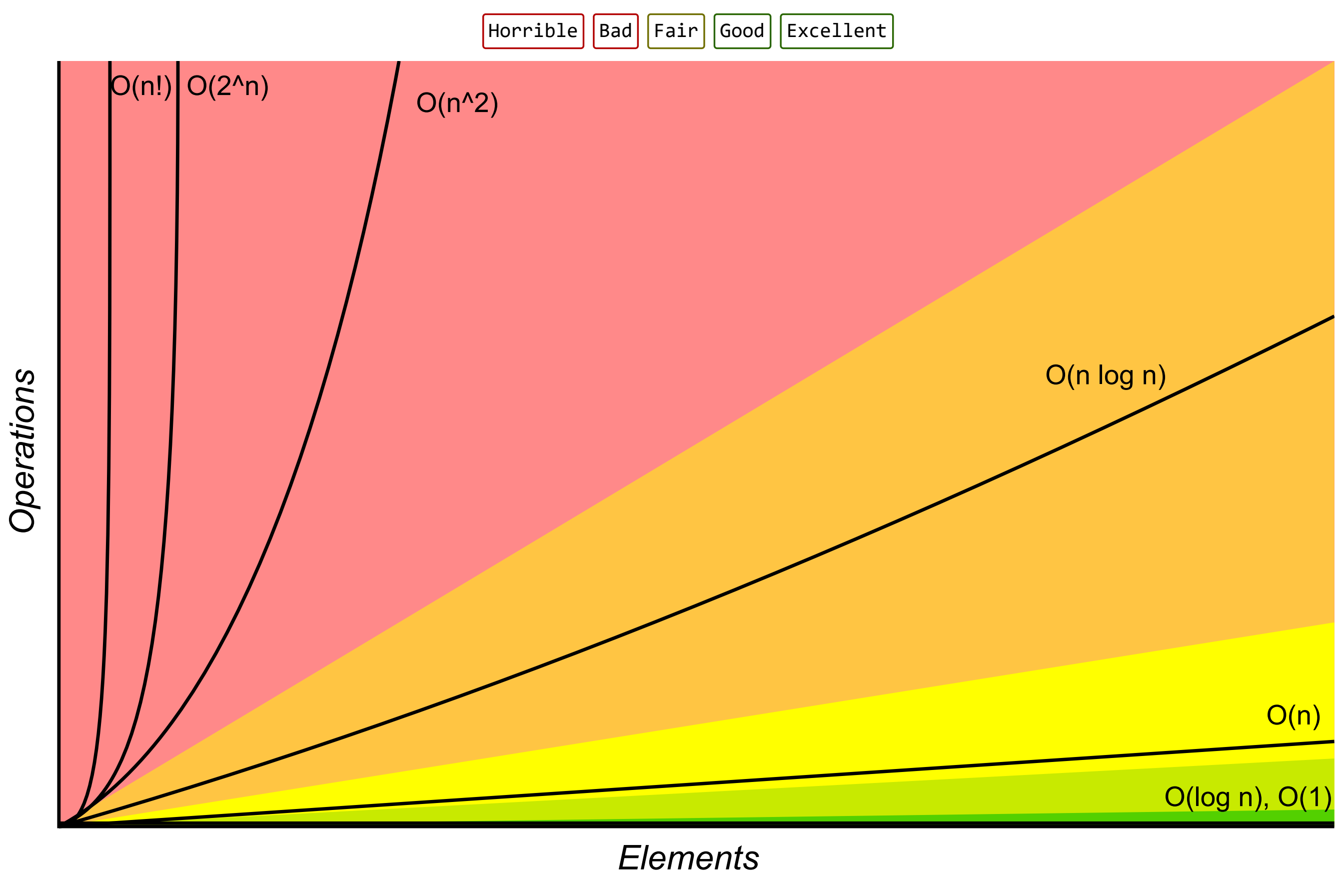
Know Thy Complexities!

Hi there! This webpage covers the space and time Big-O complexities of common algorithms used in Computer Science. When preparing for technical interviews in the past, I found myself spending hours crawling the internet putting together the best, average, and worst case complexities for search and sorting algorithms so that I wouldn't be stumped when asked about them. Over the last few years, I've interviewed at several Silicon Valley startups, and also some bigger companies, like Google, Facebook, Yahoo, LinkedIn, and Uber, and each time that I prepared for an interview, I thought to myself "Why hasn't someone created a nice Big-O cheat sheet?". So, to save all of you fine folks a ton of time, I went ahead and created one. Enjoy! - Eric

Big-O Complexity Chart



Common Data Structure Operations

Data Structure	Time Complexity								Space Complexity
	Average				Worst				Worst
	Access	Search	Insertion	Deletion	Access	Search	Insertion	Deletion	
Array	Θ(1)	Θ(n)	Θ(n)	Θ(n)	O(1)	O(n)	O(n)	O(n)	O(n)
Stack	Θ(n)	Θ(n)	Θ(1)	Θ(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Queue	Θ(n)	Θ(n)	Θ(1)	Θ(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Singly-Linked List	Θ(n)	Θ(n)	Θ(1)	Θ(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Doubly-Linked List	Θ(n)	Θ(n)	Θ(1)	Θ(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Skip List	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(n)	O(n)	O(n)	O(n)	O(n log(n))
Hash Table	N/A	Θ(1)	Θ(1)	Θ(1)	N/A	O(n)	O(n)	O(n)	O(n)
Binary Search Tree	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(n)	O(n)	O(n)	O(n)	O(n)
Cartesian Tree	N/A	Θ(log(n))	Θ(log(n))	Θ(log(n))	N/A	O(n)	O(n)	O(n)	O(n)
B-Tree	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)
Red-Black Tree	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)
Splay Tree	N/A	Θ(log(n))	Θ(log(n))	Θ(log(n))	N/A	O(log(n))	O(log(n))	O(log(n))	O(n)
AVL Tree	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)
KD Tree	Θ(log(n))	Θ(log(n))	Θ(log(n))	Θ(log(n))	O(n)	O(n)	O(n)	O(n)	O(n)

Array Sorting Algorithms

Algorithm	Time Complexity			Space Complexity
	Best	Average	Worst	Worst
Quicksort	Ω(n log(n))	Θ(n log(n))	O(n^2)	O(log(n))
Mergesort	Ω(n log(n))	Θ(n log(n))	O(n log(n))	O(n)
Timsort	Ω(n)	Θ(n log(n))	O(n log(n))	O(n)
Heapsort	Ω(n log(n))	Θ(n log(n))	O(n log(n))	O(1)
Bubble Sort	Ω(n)	Θ(n^2)	O(n^2)	O(1)
Insertion Sort	Ω(n)	Θ(n^2)	O(n^2)	O(1)
Selection Sort	Ω(n^2)	Θ(n^2)	O(n^2)	O(1)
Tree Sort	Ω(n log(n))	Θ(n log(n))	O(n^2)	O(n)
Shell Sort	Ω(n log(n))	Θ(n(log(n))^2)	O(n(log(n))^2)	O(1)
Bucket Sort	Ω(n+k)	Θ(n+k)	O(n^2)	O(n)
Radix Sort	Ω(nk)	Θ(nk)	O(nk)	O(n+k)
Counting Sort	Ω(n+k)	Θ(n+k)	O(n+k)	O(k)
Cubesort	Ω(n)	Θ(n log(n))	O(n log(n))	O(n)

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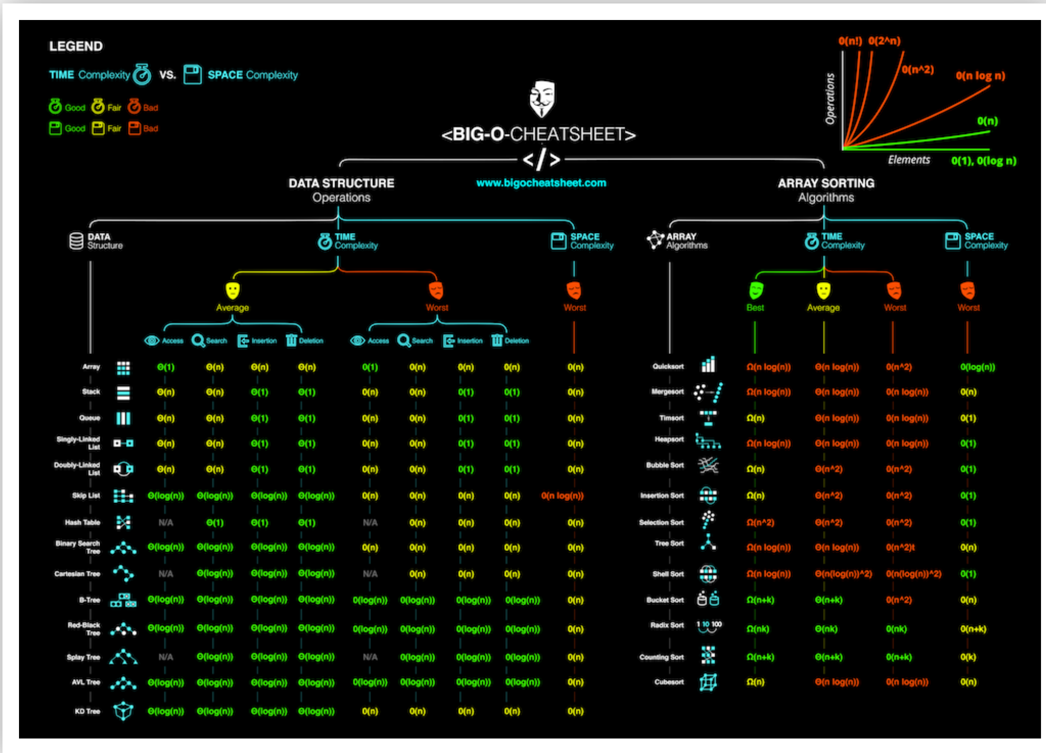
Cracking the Coding Interview: 150 Programming Questions and Solutions

Introduction to Algorithms, 3rd Edition

[Data Structures and Algorithms in Java (2nd Edition)](#)

[High Performance JavaScript (Build Faster Web Application Interfaces)](#)

Get the Official Big-O Cheat Sheet Poster



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Make this Page Better

[Edit these tables!](#)

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Name

Michael Mitchell • 8 years ago

This is great. Maybe you could include some resources (links to khan academy, mooc etc) that would explain each of these concepts for people trying to learn them.

382 ^ | v 1 • Reply • Share ›

Amanda Harlin ➦ Michael Mitchell • 8 years ago

Yes! Please & thank you

83 ^ | v • Reply • Share ›

Asim Ahmad ➦ Amanda Harlin • 3 years ago

Can you Explain the Above Algorithm.??

^ | v 9 • Reply • Share ›

Anonymous ➦ Asim Ahmad • 3 years ago

Mr.
you can learn these algorithms easily in google by searching
Don't always ask or wait for someone to post things for you go out and search on internet
You will find everything you want to learn

If you are a beginner in Data structures and algorithms then visit mycodeschool youtube channel and learn there
if you want more then email me at rise.d1105@gmail.com I will help you as much as I can

35 ^ | v 10 • Reply • Share ›

Careerdrill ➦ Anonymous • 10 months ago

https://www.careerdrill.com/

^ | v 1 • Reply • Share ›

Trey Huffine ➦ Asim Ahmad • 6 months ago

https://skilled.dev provides a detailed explanation

1 ^ | v • Reply • Share ›

Cam Cecil ➦ Michael Mitchell • 8 years ago

This explanation in 'plain English' helps:
http://stackoverflow.com/qu

http://stackoverflow.com/qu...

36 | 1 • Reply • Share ›

Richard Wheatley Cam Cecil • 5 years ago

this is plain english.

14 | 3 • Reply • Share ›

Arjan Nieuwenhuizen Michael Mitchell • 8 years ago • edited

Here are the links that I know of.

#1) http://aduni.org/courses/al...
#2) http://ocw.mit.edu/courses/...
#3) https://www.udacity.com/cou...

probably as good or maybe better # 2, but I have not had a chance to look at it.
http://ocw.mit.edu/courses/...

Sincerely,
Arjan

p.s.
https://www.coursera.org/co...
This course has just begun on coursera (dated 1 July 2013), and looks very good.

22 | • Reply • Share ›

fireheron Arjan Nieuwenhuizen • 7 years ago

Thank you Arjan. Espaecially the coursera.org one ;-)

5 | • Reply • Share ›

@hangtwentyy fireheron • 6 years ago

also this! http://opendatastructures.org

8 | • Reply • Share ›

yth @hangtwentyy • 6 years ago

thank you for sharing this.

1 | • Reply • Share ›

Eduardo Sánchez Michael Mitchell • 5 years ago

There is an amazing tutorial for Big O form Derek Banas in Youtube, that guy is amazing explaining!!!

see more

12 ^ | v • Reply • Share ›

Sudhanshu Mishra ➦ Eduardo Sánchez
• 5 years ago

Cool! This is a more than adequate introduction! Thanks a ton for sharing!

1 ^ | v • Reply • Share ›

Mohammed Hameed ➦ Eduardo Sánchez
• 2 years ago

Thanks...

^ | v • Reply • Share ›

CodeMunkey ➦ Michael Mitchell • 4 years ago

Not sure if this helps, but here's a more visual learner for some of these algorithms - if you're interested.
http://visualgo.net

4 ^ | v • Reply • Share ›

Divyendra Patil ➦ Michael Mitchell • 3 years ago

www.codenza.us

2 ^ | v • Reply • Share ›

Trey Huffine ➦ Michael Mitchell • 6 months ago

https://skilled.dev/ for a detailed explanation on Big O

1 ^ | v • Reply • Share ›

nate lipp ➦ Michael Mitchell • 4 years ago

This is a well put together introduction
https://www.interviewcake.c...

1 ^ | v • Reply • Share ›

Abby Jones ➦ Michael Mitchell • a year ago

Fabulous idea!

^ | v • Reply • Share ›

Jeshika Morneau ➦ Michael Mitchell • 2 years ago

Or you could have supplied them in your comment instead.

^ | v • Reply • Share ›

Nhập Hàng Ngoại ➦ Michael Mitchell • 4 years ago

http://fashionfor.life/t-sh...

see more

13 • Reply • Share ›

Blake Jennings • 8 years ago

i'm literally crying

101 • Reply • Share ›

friend → Blake Jennings • 4 years ago

you give me a big o

5 • Reply • Share ›

Gokce Toykuyu • 8 years ago

Could we add some tree algorithms and complexities? Thanks. I really like the Red-Black trees ;)

91 • Reply • Share ›

ericdrowell Mod → Gokce Toykuyu • 8 years ago

Excellent idea. I'll add a section that compares insertion, deletion, and search complexities for specific data structures

31 • Reply • Share ›

yash bedi → ericdrowell • 4 years ago

its been 4 years you haven't added that section :)

• Reply • Share ›

Elliot Géhin → yash bedi • 4 years ago

It's up there Yash, bottom of the first table

1 • Reply • Share ›

Ahsan Sukamuljo → yash bedi • 10 months ago

fuck off asshole

3 • Reply • Share ›

Jonathan Neufeld → Gokce Toykuyu • 3 years ago

Where I come from we use trees on a regular rotation

3 • Reply • Share ›

Valentin Stanciu • 8 years ago

1. Deletion/insertion in a single linked list is implementation

dependent. For the question of "Here's a pointer to an element, how much does it take to delete it?", single-linked lists take O(N) since you have to search for the element that points to the element being deleted. Double-linked lists solve this problem.
2. Hashes come in a million varieties. However with a good distribution function they are O(logN) worst case. Using a double hashing algorithm, you end up with a worst case of O(loglogN).
3. For trees, the table should probably also contain heaps and the complexities for the operation "Get Minimum".

63 ^ | ˅ • Reply • Share ›

Alexis Mas ➦ Valentin Stanciu • 7 years ago

If you a list: A B C D, When you want to delete B, you can delete a node without iterating over the list.

1. B.data = C.data
2. B.next = C.next
3. delete C

If you can't copy data between nodes because its too expensive then yes, it's O(N)

6 ^ | ˅ 1 • Reply • Share ›

Miguel ➦ Alexis Mas • 6 years ago

You still have to find the position in the list, which can only be done linearly.

7 ^ | ˅ • Reply • Share ›

Guest ➦ Miguel • 6 years ago • edited

You still have to find the position in the list, which can only be done linearly.

3 ^ | ˅ • Reply • Share ›

Alexis Mas ➦ Miguel • 6 years ago

Yes of course, If you need to search the node it's O(n), otherwise you can delete it as I stated before.

1 ^ | ˅ • Reply • Share ›

Guest ➦ Alexis Mas • 6 years ago

No need to find the position if you can delete it as Alexis mentioned

2 ^ | ˅ 1 • Reply • Share ›

OmegaNemesis28 ➦ Alexis Mas
• 6 years ago • edited

To get to B - you HAVE to iterate over the list though. You can't just manipulate B without a pointer. So unless you do book-keeping and have pointers to specific nodes you intend to delete/manipulate, LinkLists are O(n) insert and delete.

3 ^ | ˅ • Reply • Share ›

Alexis Mas ➜ OmegaNemesis28
• 6 years ago

Strictly speaking no, you don't. let's say you have this function.

public void delete(Node node)

That function doesn't care how did you got that node.

Did you got my point?

When you have a pointer to a node, and that node needs to be deleted you don't need to iterave over the list.

1 ^ | ˅ 2 • Reply • Share ›

Sam Lehman ➜ Alexis Mas • 6 years ago

But in order to get to that pointer, you probably need to iterate through the list

2 ^ | ˅ • Reply • Share ›

OmegaNemesis28 ➜ Alexis Mas
• 6 years ago • edited

But that is MY point :p

You have to have the node FIRST. You have to iterate through the list before you can do that, unless you do book-keeping and happen to have said node. Reread what I said. "have pointers to specific nodes" Most of the time, you do not with LinkedLists. If you have a Linked List and want to delete index 5, you have to iterate to 5 and such. Your example was ABCD, our points are that you typically don't have the pointer to B just offhand. You have to obtain it first which will be O(n)

2 ^ | ˅ • Reply • Share ›

Chris B ➜ OmegaNemesis28
• 5 years ago