codecademy

Big-O Notation: Time and Space Complexity

Big-Θ Notation

We compute the big-Θ of an algorithm by counting the number of iterations the algorithm *always* takes with an input of n. For instance, the loop in the pseudo code below will always iterate N times for a list size of N. The runtime can be described as Θ(N).

```
for each item in list:
  print item
```

Asymptotic Notation

Asymptotic Notation is used to describe the running time of an algorithm - how much time an algorithm takes with a given input, n. There are three different notations: big O, big Theta (Θ), and big Omega (Ω). big-Θ is used when the running time is the same for all cases, big-O for the worst case running time, and big-Ω for the best case running time.

Adding Runtimes

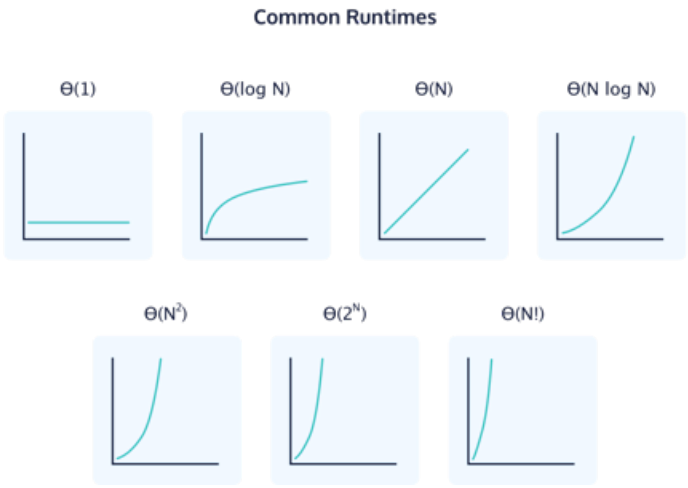
When an algorithm consists of many parts, we describe its runtime based on the slowest part of the program.

An algorithm with three parts has running times of Θ(2N) + Θ(log N) + Θ(1). We only care about the slowest part, so we would quantify the runtime to be Θ(N). We would also drop the coefficient of 2 since when N gets really large, the multiplier 2 will have a small effect.

Algorithmic Common Runtimes

The common algorithmic runtimes from fastest to slowest are:

- constant: Θ(1)
- logarithmic: Θ(log N)
- linear: Θ(N)
- polynomial: Θ(N^2)
- exponential: Θ(2^N)
- factorial: Θ(N!)



Big-O Notation

The Big-O notation describes the worst-case running time of a program. We compute the Big-O of an algorithm by counting how many iterations an algorithm will take in the worst-case scenario with an input of N. We typically consult the Big-O because we must always plan for the worst case. For example, O(log n) describes the Big-O of a binary search algorithm.

Big-Ω Notation

Big-Ω (Omega) describes the best running time of a program. We compute the big-Ω by counting how many iterations an algorithm will take in the best-case scenario based on an input of N. For example, a Bubble Sort algorithm has a running time of Ω(N) because in the best case scenario the list is already sorted, and the bubble sort will terminate after the first iteration.

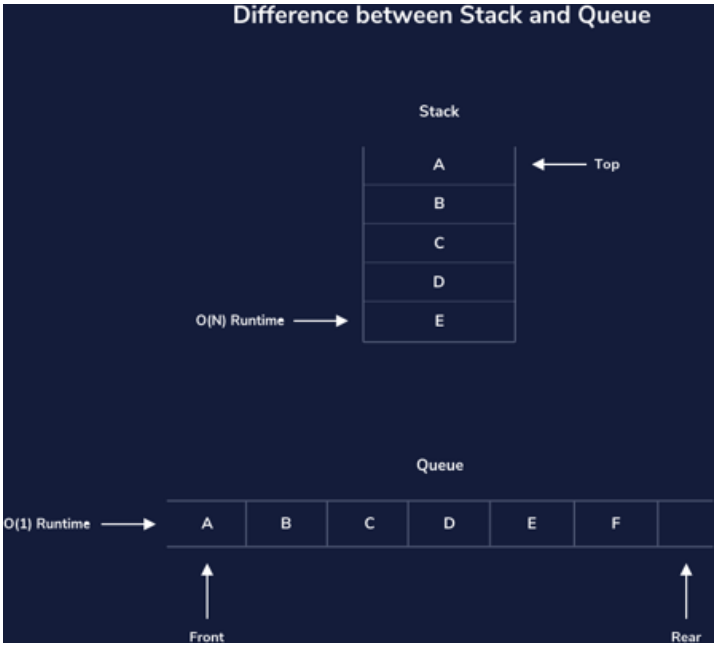
Analyzing Runtime

The speed of an algorithm can be analyzed by using a while loop. The loop can be used to count the number of iterations it takes a function to complete.

```
def half(N):
  count = 0
  while N > 1:
    N = N//2
    count += 1
  return count
```

Queue Versus Stack

A `Queue` data structure is based on First In First Out order. It takes O(1) runtime to retrieve the first item in a `Queue`. A `Stack` data structure is based on First In Last Out order. Therefore, it takes O(N) runtime to retrieve the first value in a `Stack` because it is all the way at the bottom.



Max Value Search in List

The big-O runtime for locating the maximum value in a list of size N is O(N). This is because the entire list of N members has to be traversed.

```
# O(N) runtime
def find_max(linked_list):
  current = linked_list.get_head_node()
  maximum = current.get_value()
  while current.get_next_node():
    current = current.get_next_node()
    val = current.get_value()
    if val > maximum:
      maximum = val
  return maximum
```

Bubble Sort with Linked List

Bubble Sort is the simplest sorting algorithm for a list. For every element in the list, it compares it with its subsequent neighbor and swaps them if they are in descending order. Each pass of the swap takes O(N). Since there are N elements in the list, it would take N*N swaps. The Big O runtime would be O(N^2).

 Print  Share