RUNNING TIME ANALYSIS - PART 2
BINARY SEARCH TREES RUNNING TIME

Problem Solving with Computers-II

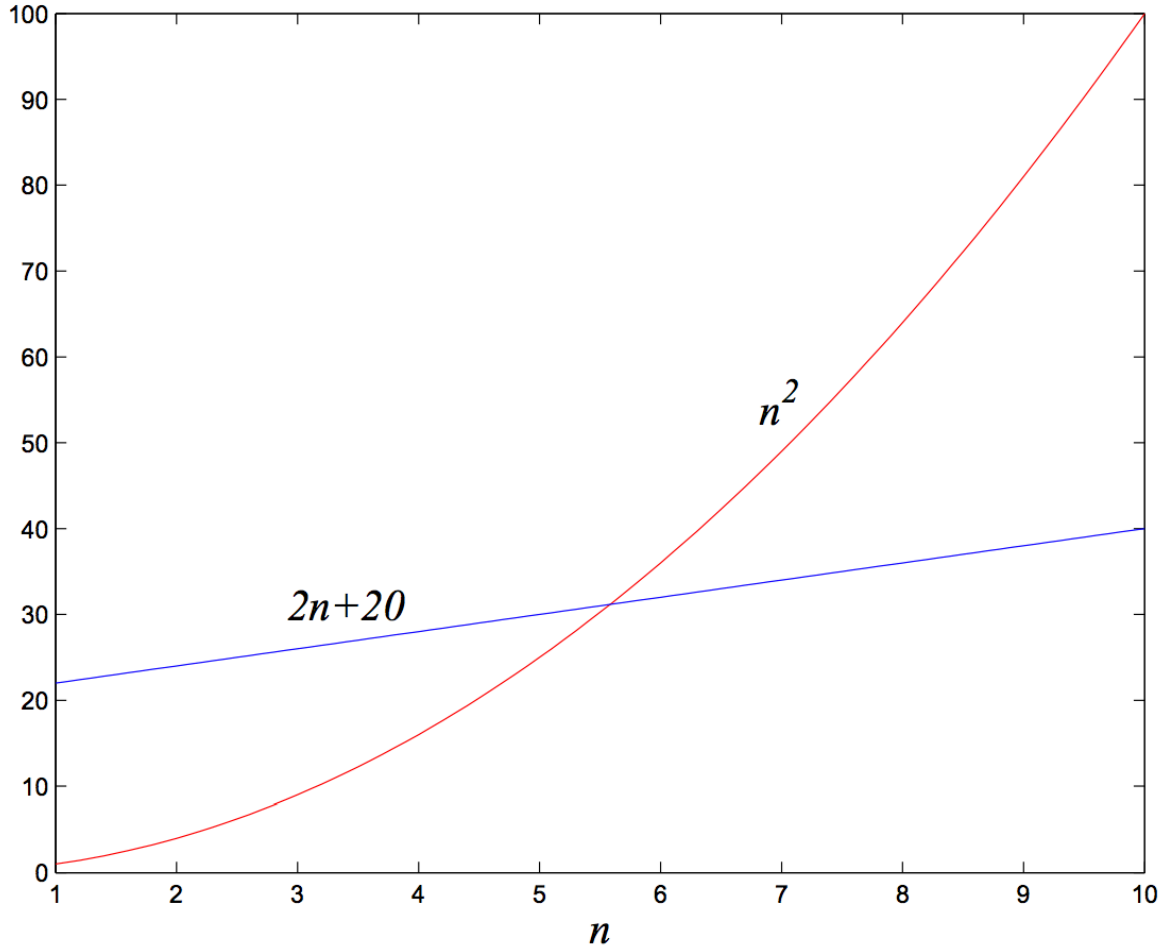
What does Big-Oh really mean?

Formal definition of Big-O

- f(n) and g(n): running times of two algorithms on inputs of size n.
- f(n) and g(n) map positive integer inputs to positive reals.

We say f = O(g) if there is a constant $c > 0$ and $k>0$ such that
$f(n) \leq c \cdot g(n)$ for all $n >= k$.

f = O(g)
means that "f grows no faster than g"

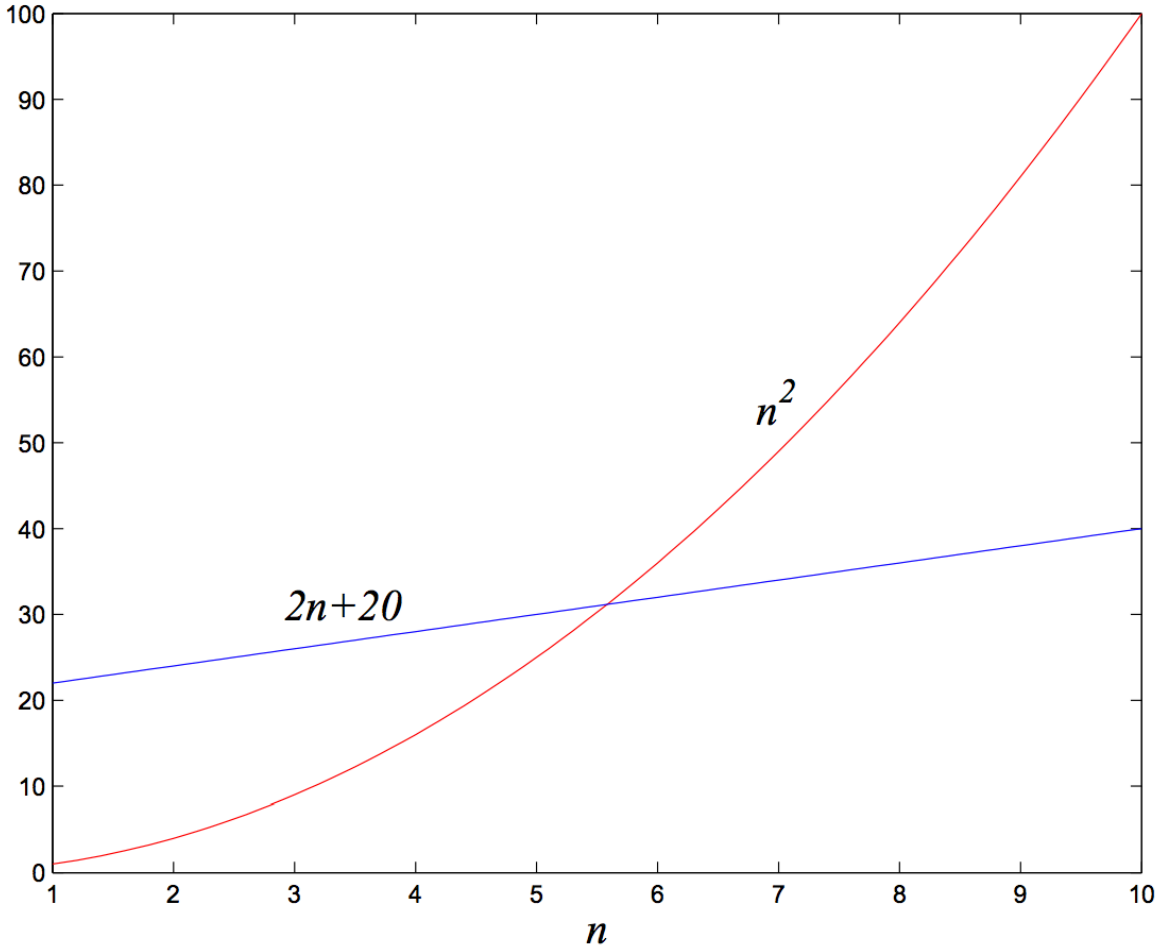


Big-Omega

- f(n) and g(n): running times of two algorithms on inputs of size n.
- f(n) and g(n) map positive integer inputs to positive reals.

We say $f = \Omega(g)$ if there are constants
$c > 0, k>0$ such that $c \cdot g(n) \leq f(n)$
for $n >= k$

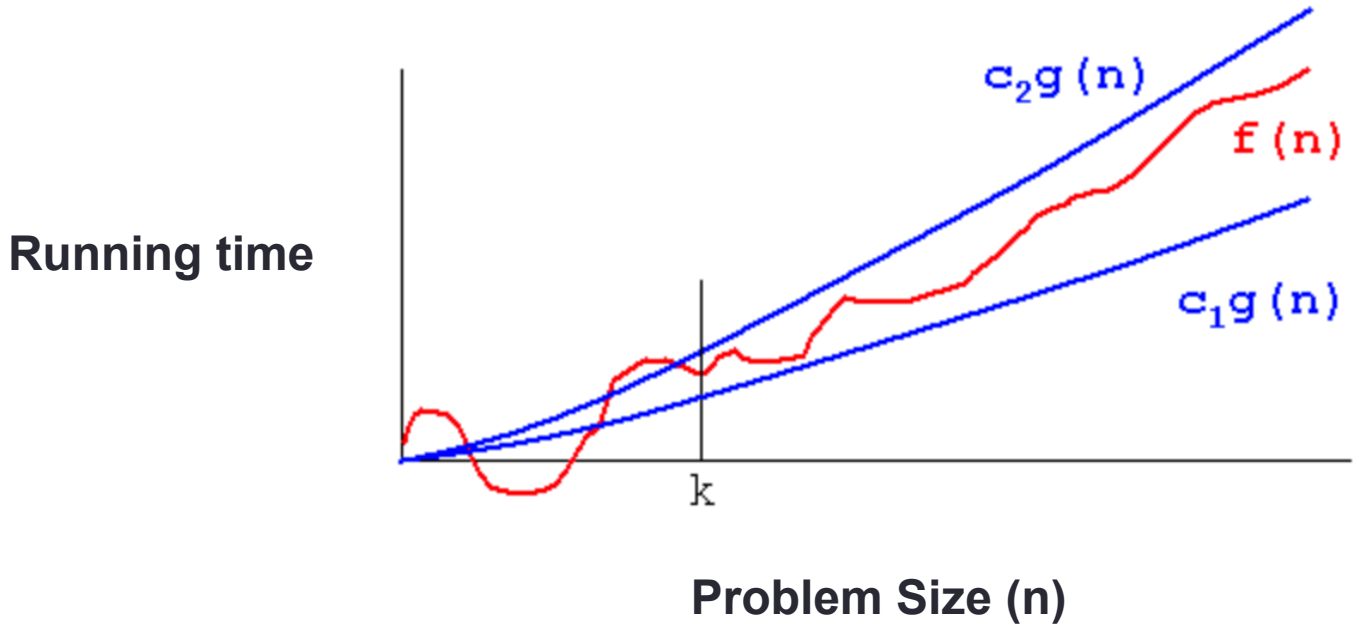
$f = \Omega(g)$
means that "f grows at least as fast as g"



Big-Theta

- f(n) and g(n): running times of two algorithms on inputs of size n.
- f(n) and g(n) map positive integer inputs to positive reals.

We say $f = \Theta(g)$ if there are constants $c_1, c_{2\ ,k}$ such that $0 \leq c_1 g(n) \leq f(n) \leq c_2 g(n)$, for $n >= k$



What is the Big-O running time of algoX?

- Assume **dataA** is some data structure.
- Given: running time of operations for dataA, where M is the number of keys stored in dataA
  - insert: O(log M)
  - min: O(1)
  - delete: O(log M)

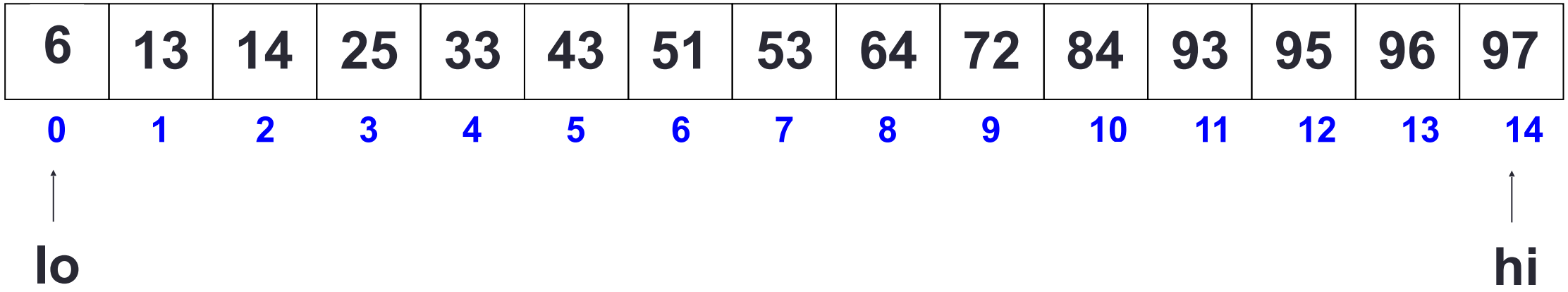
```
void algoX(int arr[], int N)
{
        dataA ds;//ds contains no keys
        for(int i=0; i < N; i++)
                ds.insert(arr[i]);
        for(int i=0; i < N; i++){
                arr[i] = ds.min();
                ds.delete(arr[i]);
        }
}
```

A. $O(N^2)$
B. O(N logN)
C. O(N)
D. O(log N)
E. Not enough information to compute

Best case, worst case, average case running times

Operations on sorted arrays

- Min :
- Max:
- Median:
- Successor:
- Predecessor:
- Search:
- Insert :
- Delete:



Worst case analysis of binary search

```
bool binarySearch(int arr[], int element, int N){
//Precondition: input array arr is sorted in ascending order
  int begin = 0;
  int end = N-1;
  int mid;
  while (begin <=  end){
    mid = (end + begin)/2;
    if(arr[mid]==element){
      return true;
    }else if (arr[mid]< element){
      begin = mid + 1;
    }else{
      end = mid - 1;

    }
  }
  return false;
}
```