

CSE / ENGR 142 Programming I

Linear & Binary Search

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K1-1

Searching

- Searching = looking for something
- Searching an array is particularly common
 - Goal: determine if a particular value is in the array
- If the array is unsorted:
 - start at the beginning and look at each element to see if it matches

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K1-2

Linear Search

```
/* If x appears in a[0..n-1], return its location, i.e.,  
   return k where a[k]=x. If x not found, return -1 */  
int search (int a[], int n, int x) {  
    int loc = 0;  
    while (loc < n && a[loc] != x)  
        loc++;  
    if (loc < n)  
        return loc  
    else return -1;  
}
```

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K1-3

Linear Search

v	3	12	-5	6	142	21	-17	45
---	---	----	----	---	-----	----	-----	----

- Test:
 search(v, 8, 12)
 search(v, 8, 15)
- Note: Condition in while relies on short-circuit evaluation of && (i.e., a[loc] might not be defined if loc >= n).

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K1-4

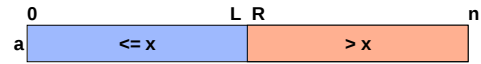
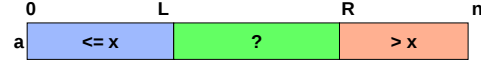
Can we do better?

- "Binary search" works if the array is sorted
 1. Look for the target in the middle.
 2. If you don't find it, you can ignore half of the array, and repeat the process with the other half.
- Example: Find first page of Pizza listings in the yellow pages

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K1-5

Binary Search Strategy

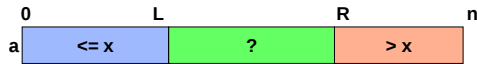
- What we want: Find split between values larger and smaller than x:

- Situation while searching

- Step: Look at a[(L+R)/2]. Move L or R to the middle depending on test.

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K1-6

Binary Search Strategy

- More precisely



Values in $a[0..L]$ $\leq x$

Values in $a[R..n-1]$ $> x$

Values in $a[L+1..R-1]$ are unknown

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K1-7

Binary Search

/ If x appears in $a[0..n-1]$, return its location, i.e., return k where $a[k]=x$. If x not found, return -1 */*

```
int bsearch (int a[ ], int n, int x) {
    int L, R, mid;
    _____ ;
    while ( _____ ) {
```

_____ ;

} _____ ;

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K1-8

Binary Search

/ If x appears in $a[0..n-1]$, return its location, i.e., return k where $a[k]=x$. If x not found, return -1 */*

```
int bsearch (int a[ ], int n, int x) {
    int L, R, mid;
```

```
    _____ ;
    while ( _____ ) {
```

```
        mid = (L+R) / 2;
        if (a[mid] <= x)
            L = mid;
        else R = mid;
    }
```

```
    _____ ;
} _____ ;
```

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K1-9

Loop Termination

/ If x appears in $a[0..n-1]$, return its location, i.e., return k where $a[k]=x$. If x not found, return -1 */*

```
int bsearch (int a[ ], int n, int x) {
    int L, R, mid;
```

```
    _____ ;
    while (  $L+1 \neq R$  ) {
```

```
        mid = (L+R) / 2;
        if (a[mid] <= x)
            L = mid;
        else R = mid;
    }
```

```
    _____ ;
} _____ ;
```

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K1-10

Return Result

/ If x appears in $a[0..n-1]$, return its location, i.e., return k where $a[k]=x$. If x not found, return -1 */*

```
int bsearch (int a[ ], int n, int x) {
    int L, R, mid;
```

```
    _____ ;
    while (  $L+1 \neq R$  ) {
        mid = (L+R) / 2;
        if (a[mid] <= x) L = mid;
        else R = mid;
    }
```

```
    if (L >= 0 && a[L] == x) return L
    else return -1;
```

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K1-11

Initialization

/ If x appears in $a[0..n-1]$, return its location, i.e., return k where $a[k]=x$. If x not found, return -1 */*

```
int bsearch (int a[ ], int n, int x) {
    int L, R, mid;
```

```
    L = -1; R = n;
    while (  $L+1 \neq R$  ) {
        mid = (L+R) / 2;
        if (a[mid] <= x) L = mid;
        else R = mid;
    }
```

```
    if (L >= 0 && a[L] == x) return L
    else return -1;
```

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K1-12

Binary Search

v	-17	-5	3	6	12	21	45	142
---	-----	----	---	---	----	----	----	-----

- Test: `bsearch(v,8,3);`

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K1-13

Binary Search

v	-17	-5	3	6	12	21	45	142
---	-----	----	---	---	----	----	----	-----

- Test: `bsearch(v,8,17);`

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K1-14

Binary Search

vec	-17	-5	3	6	12	21	45	142
-----	-----	----	---	---	----	----	----	-----

- Test: `bsearch(vec,8,143);`

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K1-15

Binary Search

vec	-17	-5	3	6	12	21	45	142
-----	-----	----	---	---	----	----	----	-----

- Test: `bsearch(vec,8,-143);`

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K1-16

Is it worth the trouble?

- Suppose you had 1000 elements
- Ordinary search would require maybe 500 comparisons on average
- Binary search
 - after 1st compare, throw away half, leaving 500 elements to be searched.
 - after 2nd compare, throw away half, leaving 250. Then 125, 63, 32, 16, 8, 4, 2, 1 are left.
 - After at most 10 steps, you're done!

What if you had 1,000,000 elements??

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K1-17