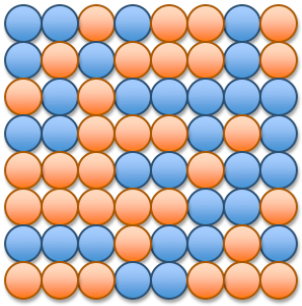
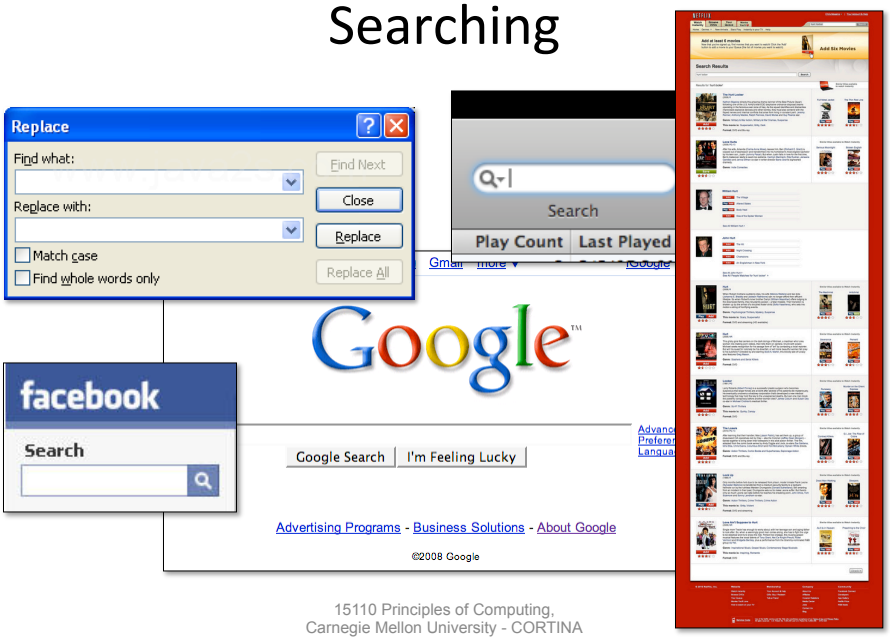


UNIT 4A
Iteration: Searching

Goals of this Unit

- Study an iterative algorithm called linear search that finds the first occurrence of a target in a collection of data.
- Study an iterative algorithm called insertion sort that sorts a collection of data into non-decreasing order.
- Learn how these algorithm scale as the size of the collection grows.
- Express the amount of work each algorithm performs as a function of the amount of data being processed.

Searching



Built-in Search in Python

```
movies = ["up", "wall-e", "toy story",
  "monsters inc", "cars", "bugs life",
  "finding nemo", "the incredibles",
  "ratatouille"]
movies.index("cars")        => 4
movies.index("shrek")       => error
movies.index("Up")          => error
"wall-e" in movies          => True
"toy" in movies             => False
```

A Little More about Strings

You can use relational operators to compare strings.

Comparisons are done character by character using ASCII codes.

```
"smithers" > "burns"        => True
"homer" < "marge"           => True
“homer" < “Marge"           => False
"clancy" > "cletus"         => False
"bart" < "bartholomew"      => True
```


Extended ASCII table

1 ┌	33 !	65 A	97 a	129 ü	161 ¡	193 Á	225 á
2 ┐	34 "	66 B	98 b	130 ,	162 ¢	194 Â	226 â
3 └	35 #	67 C	99 c	131 ƒ	163 £	195 Ã	227 ã
4 ┘	36 $	68 D	100 d	132 „	164 ¤	196 Ä	228 ä
5 |	37 %	69 E	101 e	133 …	165 ¥	197 Å	229 å
6 ─	38 &	70 F	102 f	134 †	166 ¦	198 Æ	230 æ
7 •	39 '	71 G	103 g	135 ‡	167 §	199 Ç	231 ç
8 ◘	40 (	72 H	104 h	136 ^	168 ¨	200 È	232 è
9	41)	73 I	105 i	137 ‰	169 ©	201 É	233 é
10	42 *	74 J	106 j	138 Š	170 ª	202 Ê	234 ê
11 ♂	43 +	75 K	107 k	139 ‹	171 «	203 Ë	235 ë
12 ◘	44 ,	76 L	108 l	140 Œ	172 ¬	204 Ì	236 ì
13	45 -	77 M	109 m	141 ï	173 -	205 Í	237 í
14 ♫	46 .	78 N	110 n	142 Ž	174 ®	206 Î	238 î
15 ☼	47 /	79 O	111 o	143 ï	175 ¯	207 Ï	239 ï
16 ►	48 0	80 P	112 p	144 ï	176 °	208 Ð	240 ð
17 ◄	49 1	81 Q	113 q	145 '	177 ±	209 Ñ	241 ñ
18 ↕	50 2	82 R	114 r	146 '	178 ²	210 Ò	242 ò
19 ‼	51 3	83 S	115 s	147 "	179 ³	211 Ó	243 ó
20 ¶	52 4	84 T	116 t	148 "	180 ´	212 Ô	244 ô
21 §	53 5	85 U	117 u	149 •	181 µ	213 Õ	245 õ
22 ▬	54 6	86 V	118 v	150 –	182 ¶	214 Ö	246 ö
23 ↨	55 7	87 W	119 w	151 —	183 ·	215 ×	247 ÷
24 ↑	56 8	88 X	120 x	152 ˜	184 ¸	216 Ø	248 ø
25 ↓	57 9	89 Y	121 y	153 ™	185 ¹	217 Ù	249 ù
26 →	58 :	90 Z	122 z	154 š	186 º	218 Ú	250 ú
27 ←	59 ;	91 [	123 {	155 ›	187 »	219 Û	251 û
28	60 <	92 \	124 |	156 œ	188 ¼	220 Ü	252 ü
29	61 =	93]	125 }	157 ï	189 ½	221 Ý	253 ý
30	62 >	94 ^	126 ~	158 ž	190 ¾	222 Þ	254 þ
31	63 ?	95 _	127 □	159 Ÿ	191 ¿	223 ß	255 ÿ
32	64 @	96 `	128 €	160	192 À	224 à	

Containment

Design an algorithm that returns **`True`** if a list contains a desired "key", or **`False`** otherwise.

A `contains` method

```
def contains(list, key):
    index = 0
    while index < len(list):
        if list[index] == key:
            return True
        index = index + 1
    return False
```

What happens if we execute **`return`** before we reach the end of the method?

A `contains` method – version 2

```
def contains(list, key):
    for item in list:
        if item == key:
            return True
    return False
```


Search

Design an algorithm that returns the index of the first occurrence of a key in a list if the key is present, or **`None`** otherwise.

A **search** method

```
def search(list, key):
    index = 0
    while index < len(list):
        if list[index] == key:
            return index
        index = index + 1
    return None
```


Not valid...

```
def search(list, key):
    for item in list:
        if item == key:
            return index
    return None
```

Why can't we do this?

Ok, but...

```
def search(list, key):
    for item in list:
        if item == key:
            return list.index(key)
    return None
```

What's undesirable about this?

Comparing Algorithms and Programs

- There may be many different algorithms for solving the same problem and different implementations of them as programs
- We can compare how efficient they are both analytically and empirically

Which One is Faster?

```
def contains1(list, key):
  index = 0
  while index < len(list):
    if list[index] == key:
      return True
    index = index + 1
  return False
```

```
def contains2(list, key):
  n = len(list)
  index = 0
  while index < n:
    if list[index] == key:
      return True
    index = index + 1
  return False
```

len(list) is executed each time loop condition is checked

len(list) is executed only once and its value is stored in n

Empirical Comparison Based on Running Time

•Add the following function to our collection of contains functions from the previous page:

```
def contains3(list, key):
    for index in range(len(list)):
        if list[index] == key:
            return True
    return False
```

Measuring Runtimes

```
import time
size = 1000000
list1 = [None] * size
l2string = "This is a very long and complicated string with lots of characters."
list2 = [l2string] * size
l2probe = "This is a very long and complicated string with lots of characters?"

start = time.time()
contains1(list1, -1)
runtime = time.time() – start
print("contains1 on list1:", runtime)
```

Also do this for contains2, contains3

```
start = time.time()
contains1(list2, l2probe)
runtime =  time.time() – start
print("contains1 on list2:", runtime)
```

Also do this for contains2, contains3

```
contains1 on list1: 0.17847990989685059
contains2 on list1: 0.11864590644836426
contains3 on list1: 0.07513308525085449
contains1 on list2: 0.2790398597717285
contains2 on list2: 0.20592999458312988
contains3 on list2: 0.1643359661102295
```

Python range loop is faster

String comparison is expensive

Roughly 50ns per statement