

## Objectives

- Search strategies

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## Lab 10

- Trying to solve a real problem
- Started with designing the solution from a vague specification
- Broke into smaller problems (different classes, different responsibilities)
- Implementing smaller components
- Building to large component

Demonstration of Example UI

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## Lab 10 Discussion

- What is the API for the Person class?
- What is the API for the SocialNetwork class?

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## APIs

### Person

- Person(id)
- str(person)
- getName()
- getNetwork()
- getFriends()
- getNumberOfFriends()
- getId()
- setName(newName)
- setNetwork(newNetwork)
- addFriend(person)

### SocialNetwork

- SocialNetwork()
- str(socialNetwork)
- getPerson(id)
- getPeople()
- getUserIds()
- printNetwork()
- addConnection(id1, id2)
- addConnections(filename)
- ...

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## Need 2 Volunteers

- No one will get hurt ...

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## Find the Card in Your Deck

- Reminder to me: take out the jokers
- Challenge: who can find the card first
  - (Most efficient algorithm)
- Need rest of class to keep searchers honest and help me determine who found the card first

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## The Race is On!

- 3 of Hearts
- 2 of Diamonds
- 4 of Clubs
- Queen of Spades
- King of Queens

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## Searching for a Playing Card

- Given a deck of cards and a card to find, describe the algorithm for how you would find that card.
  - Present several algorithms (naïve ones too!)
  - Discuss the strengths and weaknesses of each

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## Search Using `in` Review

- Iterates through a list, checking if the element is found
- Known as **linear search**
- **Implementation:**

```
def linearSearch(searchlist, key):  
    for elem in searchlist:  
        if elem == key:  
            return True  
    return False
```

value	8	5	3	7
pos	0	1	2	3

What are the strengths and weaknesses of implementing search this way?

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search.py

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## Linear Search

- **Overview:** Iterates through a list, checking if the element is found
- **Benefits:**
  - Works on *any* list
- **Drawbacks:**
  - Does not tell us where in the list it is
    - What if wanted to do something to that element?
  - Could implement our own version that returns the position
  - Slow -- needs to check each element of list if the element is not in the list

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## High-Low Game/TPIR Clock Game

- I'm thinking of a number between 1-100
- You want to guess the number as quickly as possible (in fewest guesses)
- For every number you guess, I'll tell you if you got it right. If you didn't, I'll tell you whether you're too high or too low

Reminder: write down guesses

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## High-Low Game/TPIR Clock Game

- I'm thinking of a number between 1-100
- You want to guess the number as quickly as possible (in fewest guesses)
- For every number you guess, I'll tell you if you got it right. If you didn't, I'll tell you whether you're too high or too low

➔ What is your best guessing strategy?

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## Strategy: Eliminate Half the Possibilities

- Repeat until find value or looked through all values
  - Guess middle value of possibilities
  - If match, found!
  - Otherwise, find out too high or too low
  - Modify your possibilities
    - Eliminate the possibilities from your number and higher/lower, as appropriate
- Known as **Binary Search**

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## Searching...

value	-3	0	0	1	2	7	8	9
pos	0	1	2	3	4	5	6	7

Use algorithm to search for key = 8

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## Searching for 8

-3	0	0	1	2	7	8	9
0	1	2	3	4	5	6	7

- Find the middle of the list
  - Positions: 0-7, so mid position is  $((7+0)/2) = 3$
- Check if the key equals the value at mid (1)
  - If so, report the location
- Check if the key is higher or lower than value at mid
  - Search the appropriate half of the list

				2	7	8	9
				4	5	6	7

8 > 1, so look in upper half

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## Searching for 8

- mid is 5  $((7+4)/2)$ , list[5] is 7

2	7	8	9
4	5	6	7

8 > 7, so look in upper half

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## Searching for 8

- mid is 5  $((7+4)/2)$ , list[5] is 7
  - 8 > 7, so look in upper half
- mid is 6  $((7+6)/2)$ , list[6] is 8
  - 8 == 8, FOUND IT at position 6!

2	7	8	9
4	5	6	7

8 == 8, FOUND IT at position 6!

What if searched for 6 instead of 8?

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## Searching for 6

-3	0	0	1	2	7	8	9
0	1	2	3	4	5	6	7

- Will follow same execution flow, but 6 is not in the list
- mid is 6, list[5] is 7
  - 6 < 7, so will try to look in lower half of the list
- mid is 4, list[4] is 2
  - 6 > 2, so will try to look in upper half of the list, but we've already determined it's not there.

2	7	8	9
4	5	6	7

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How do we know to stop looking?

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## Implementation Group Work

```
def search(searchlist, key):  
    """Pre: searchlist is a list of  
    integers in sorted order. Returns the  
    position of key (an integer) in the list  
    of integers (searchlist) or -1 if not  
    found"""
```

- Trace through your program using examples
  - Start simple (small lists)
  - Do what the program says *exactly*, not what you *think* the program says

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## One Solution

Cutting list in half  
Discuss tradeoffs

```
def altBinarySearch(searchlist, key):  
    # Base Case: ran out of elements in the list  
    if len(searchlist) == 0:  
        return NOT_FOUND  
  
    low = 0  
    high = len(searchlist)-1  
    mid = (low+high)/2  
  
    valueAtMid = searchlist[mid]  
    if valueAtMid == key:  
        return mid  
    if low == high:  
        return NOT_FOUND  
  
    if searchlist[mid] < key: # search upper half  
        return altBinarySearch(searchlist[mid+1:], key)  
    else: # search lower half  
        return altBinarySearch(searchlist[:mid], key)
```

Creating a new list  
Unnecessary memory use

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## One Solution

```
def search(searchlist, key):  
    low=0  
    high = len(searchlist)-1  
    while low <= high :  
        mid = (low+high)/2  
        if searchlist[mid] == key:  
            return mid # return True  
        elif key > searchlist[mid]:  
            low = mid+1  
        else:  
            high = mid-1  
    return -1 # return False
```

If you just want to  
know if it's in the list

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search2.py

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## Binary Search

- Example of a **Divide and Conquer** algorithm
  - Break into smaller pieces that you can solve
- Benefits:
  - Faster to find elements (especially with larger lists)
- Limitations:
  - Requires that data can be compared
    - `__cmp__` method implemented by the class
  - List **must** be sorted before searching
    - Takes time to sort beforehand

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## Empirical Study of Search Techniques

**Goal:** Determine which technique is better under various circumstances

- How long does it take to find various keys?
  - Measure by the number of comparisons
  - Vary the size of the list and the keys
  - What are good tests for the lists and the keys?

search\_compare.py

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## Empirical Study of Search Techniques

- Analyzing Results ...
  - By how much did the number of comparisons for *linear search* vary?
  - By how much did the number of comparisons for *binary search* vary?
- What conclusions can you draw from these results?

search\_compare.py

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## Key Questions in Computer Science

- How can we efficiently organize data?
- How can we efficiently search for data, given various constraints?
  - Example: data may or may not be sortable
- What are the tradeoffs?

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## For Friday

- Broader Issue
  - [One of social networking articles](#)
- Lab 10

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