Plan for eleven-four

- Thinking about APTs and test problems
  - How do you choose: list, string, set, dictionary
  - Experience? How do you get that?
  - Most APTs and test problems share structure:
    - There's a loop, there's a selection/decision, update
- You can often do this with a list comprehension, but you don't have to!
  - Write code you can understand, but you must be able to read code with list comprehensions and with dictionaries

SortedFreqs

- http://www.cs.duke.edu/csed/pythonapt/sortedfreqs.html
- What do you return? How many elements does it contain? Can you categorize them?
  - Read problem, understand what to return
  - Then think about how to calculate/create values
- Is efficiency an issue with APTs?
  - Computers do millions of operations a second
  - Your time is important!
  - Always possible to get time-limit exceeded ☺

Customer Statistics

- http://www.cs.duke.edu/csed/pythonapt/customerstatistics.html
- What's returned? How many elements does it contain? Can you categorize them?
  - Read problem, understand what to return
  - Then think about how to calculate/create values
- How can you find names that occur more than once? Can you filter names/elements?
  - Filtering is a great use of list comprehensions!
  - Creating return values in correct order, issues?

Questions

http://bit.ly/101fall15-nov5-1

Shafi Goldwasser

- 2012 Turing Award Winner
- RCS professor of computer science at MIT
  - Twice Godel Prize winner
  - Grace Murray Hopper Award
  - National Academy
  - Co-inventor of zero-knowledge proof protocols

  How do you convince someone that you know [a secret] without revealing the knowledge?
- Honesty and Privacy

  Work on what you like, what feels right, I know of no other way to end up doing creative work

DictionaryTimings.py

- Updating (key,value) pairs in structures
  - Search through unordered list
  - Search through ordered list
  - Use dictionary
- Why is searching through ordered list fast?
  - Guess a number from 1 to 1000, first guess?
  - What is 2^{10}? Why is this relevant? 2^{20}?
  - Dictionary is faster! But not ordered

Linear search through list o' lists

- Maintain list of [string,count] pairs
  - List of lists, why can't we have list of tuples?

```
[ ['dog', 2], ['cat', 1], ['bug', 4], ['ant', 5] ]
```

  - If we read string 'cat', search and update

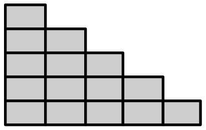
```
[ ['dog', 2], ['cat', 2], ['bug', 4], ['ant', 5] ]
```

  - If we read string 'frog', search and update

```
[ ['dog', 2],['cat', 2],['bug', 4],['ant', 5],['frog',1] ]
```

See DictionaryTimings.py

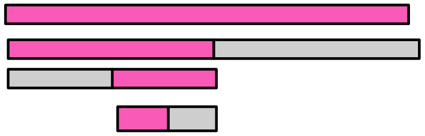
```
def linear(words):
    data = []
    for w in words:
        found = False
        for elt in data:
            if elt[0] == w:
                elt[1] += 1
                found = True
                break
        if not found:
            data.append([w,1])
    return data
```



N new words?

Binary Search

- Before the first guess, there are 1024 numbers



How many times can we divide list in half?

log$_2$(N) for N element list, why?

What must be true to use binary search?

How is this done in Python?

See DictionaryTimings.py

```
def binary(words):
    data = []
    for w in words:
        elt = [w,1]
        index = bisect.bisect_left(data, elt)
        if index == len(data):
            data.append(elt)
        elif data[index][0] != w:
            data.insert(index,elt)
        else:
            data[index][1] += 1
    return data
```

Search via Dictionary

- In linear search we looked through all pairs
- In binary search we looked at log pairs
  - But have to shift lots if new element!!
- In dictionary search we look at one pair
  - one billion, 30, 1, for example
  - Note that 2^{10} = 1024, 2^{20} = million, 2^{30}=billion
- Dictionary converts key to number, finds it
  - Need far more locations than keys
  - Lots of details to get good performance

See DictionaryTimings.py

- Finding value associated with key w:
  - Takes time independent of number of keys!

```
def dictionary(words):
    d = {}
    for w in words:
        if w not in d:
            d[w] = 1
        else:
            d[w] += 1
    return [[w,d[w]] for w in d]
```

Running times @ 10^9 instructions/sec

N	*O(log N)*	*O(N)*	*O(N log N)*	*O(N^2)*
10^2	0.0	0.0	0.0	0.00001
10^3	0.0	0.0000001	0.00001	0.001
10^6	0.0	0.001	0.02	16.7 min
10^9	0.0	1.0	29.9	31.7 years
10^{12}	9.9 secs	16.7 min	11.07 hr	31.7 million years

This is a real focus in Compsci 201

linear is N^2, binary is N log N, dictionary N

What's the best and worst case?

- If every word is the same ....
  - Does linear differ from dictionary? Why?
- Every word is different in alphabetical order
  - Does binary differ from linear? Why?
- When would dictionary be bad?
  - In practice, never, in theory, kind of the same

Practice Test Question

http://bit.ly/101fall15-test2-practice

- Read, think, read, think, plan, think, write
  - If you're not sure, come back to question
  - We won't ask you to write too much
  - It's ok to write a lot if you can't write a little