Organizing Data

The Power of Structure...

Notes for CSC 100 - The Beauty and Joy of Computing
The University of North Carolina at Greensboro

Reminders

Lab this Friday: Lists! Remember Pre-lab work.

Blown to Bits: Online discussion for Chapter 2!

Homework 1: Due Monday

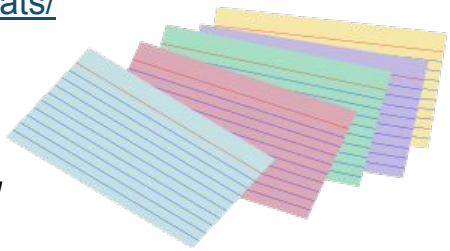
- Should have already made some significant progress!
- Submission link now available in Snap
- Last good in-class time for questions is now!

A Flood of Data

Consider the amount of data we deal with:

- Human genome: Just over 3 billion base pairs
  - *Typing in 12pt on 8.5x11 paper fits 2880 characters*
  - *So the human genome would be over a million pages (printed two-sided, an 86 foot high stack of paper)*

- Facebook - http://expandedramblings.com/index.php/by-the-numbers-17-amazing-facebook-stats/
  - *2.01 billion monthly active users (1.32 billion daily!)*
  - *Messenger+WhatsApp: Over 60 billion messages/day*
    - *On index cards, would be a stack 7500 miles high!*
  - *... or end-to-end would stretch around the world 180 times*



- Large Synoptic Survey Telescope
  - *16 terabytes (16,000,000,000,000 bytes) will be captured per day*
  - *Most of this data will never be seen by a human being*

“Big Data” is the “Big Thing”

What everyone is talking about...

Forbes | OracleVoice: Socially Aware Corporate Culture And The Give-Back Imperative | Search companies, people and lists

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Four Things You Need To Know In The Big Data Era

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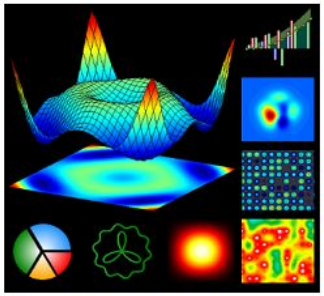
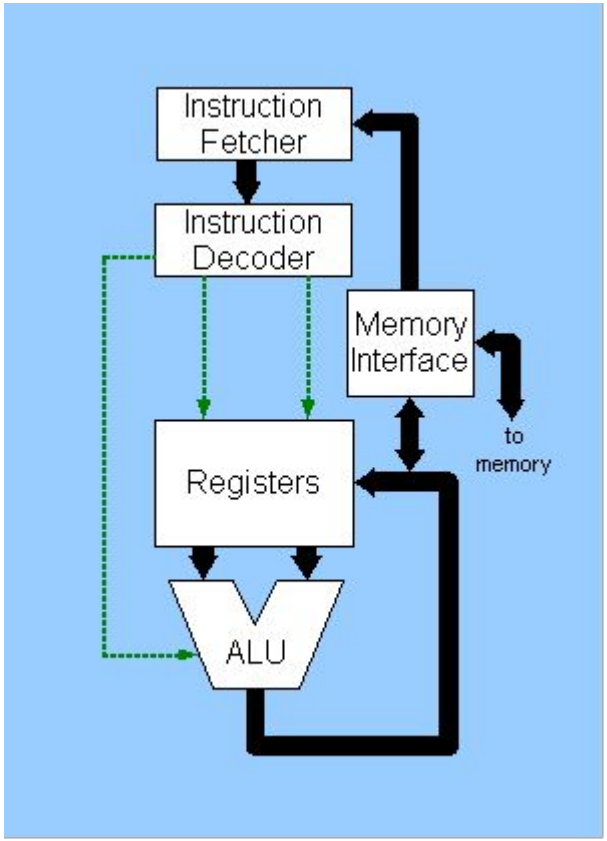


Big Data is only increasing, so what do we need to know about it? Author Phil Simon explains. (Photo credit: savoirfairelinux) (Photo credit: Wikipedia)

Big Data has been declared the “sexiest job of the 21st century” and it’s already reshaping corporate decisionmaking and even talent recruitment. As Phil Simon, author of *Too Big to Ignore: The Business Case for Big Data*, points out, “In a recent report, McKinsey estimated that the U.S. will soon face a shortage of approximately 175,000 data scientists.” Seemingly everyone wants in on Big Data, a blanket term for the massive amounts of information we generate today. (Simon notes that roughly 80 percent of that information is unstructured – such as tweets, blog posts, Facebook likes, or YouTube videos – as compared to the smaller and easier-to-manage “structured data” that populates spreadsheets.) With the impending rise of wearable technology and “The Internet of Things,” it appears the pace of data creation will only increase. Here are four things you need to know about the Era of Big Data.

Organizing Data

Until now in this class, we have talked about operations on one or two numbers at a time:



Organizing Data

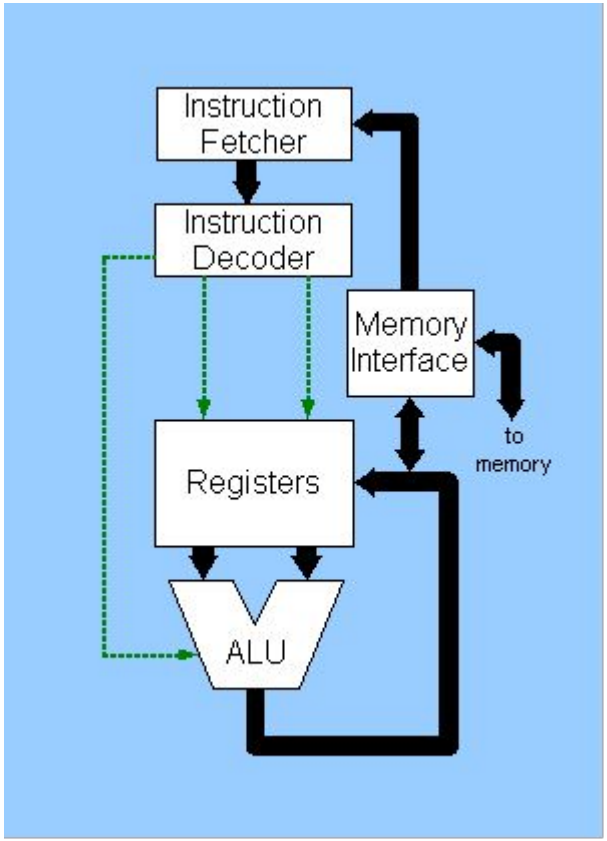
Until now in this class, we have talked about operations on one or two numbers at a time:

But we might think about operations on collections of data:

- Students in a class
- Customers of a store
- Star locations
- Messages on Facebook
- Roads in the United States

We need:

- Abstractions to think about
- Representations to implement



Abstract Data Types and Data Structures

An *abstract data type* is a type of data with associated operations, but whose representation is hidden.

Example:

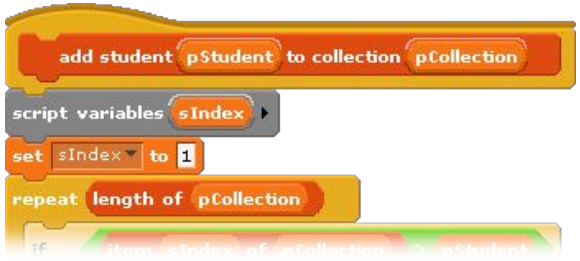
Type of data: Collection of student names

Associated operations: Add new student, delete student from collection, check if student is in collection, iterate through all students in collection

I can use this collection without worrying about how these operations are accomplished - abstraction!

A *data structure* is a particular implementation of an abstract data type.

- Determines efficiency of operations
- Roughly: Function definitions for operations



Lists - The Abstract Data Type

A “list” is a very fundamental idea in programming and in life

- Shopping lists, to-do lists, class lists, ...

Type of data: An ordered collection of items

Associated Operations:

Class Exercise: What sort of operations would you like to be able to perform on a list?

Lists - The Abstract Data Type

A “list” is a very fundamental idea in programming and in life

Type of data: An ordered collection of items

Associated Operations:

- Add an item to the front
- Add an item to the end
- Add an item at a specific position
- Delete an item from the front
- Delete an item from the end
- Delete an item from a specific position
- Check the list contains a given value
- Get the first item in the list
- Get the last item in the list
- Get the item from a specific position
- Report how many items are in the list

Lists - Programming Language View

All modern programming languages support lists!

Create and store a list

Snap!:

Python: mylist = [‘work’, ‘shop’, ‘eat’, ‘sleep’]

Java: List<String> mylist = Arrays.asList(“work”, “shop”, “eat”, “sleep”)

(Note: The Java is not really the same as the others…)

Add to the end of a list

Snap!:

Python: mylist.append(‘wake up’)

Java: mylist.add(‘eat’)

Get the 3rd item in a list

Snap!:

Python: mylist[2]

Java: mylist.get(2)

See also: http://docs.oracle.com/javase/8/docs/api/java/util/List.html

Important Points

We use lists all the time to organize things in our lives

They are just as useful for organizing data in a program

When you want to use a list, you don't really want to worry about how the computer implements the basic list operations

What we didn't talk about: There are many ways for a computer to actually store a list (many implementations)

- Some have efficient insertions and some don't
- Some use less memory than others
- Need to be more comfortable with how things are stored in memory to say much more...

A Flavor of Something More Advanced
Dictionary ADT

Type of data: Collection of pairs of items

- Each pair is a unique identifier (a key) and associated data
- Examples of pairs:
  - Student ID number and GPA (886517124 , 3.45)
  - Facebook IDs and profiles (joe@example.com , “Joe Walsh, ….”)
  - Social Security Numbers and incomes (491-24-6243 , $43,700)

Associated Operations:

- Get item from key
- Add new (key, data) pair
- Delete pair using key
- Iterate through all pairs

A Flavor of Something More Advanced

Dictionary Implementation 1 - Using a List!

Example: Storing (SSN, income) pairs

Idea 1: Keep all pairs in a list

To add a new pair:

- Put it at the end

To find an item by key:

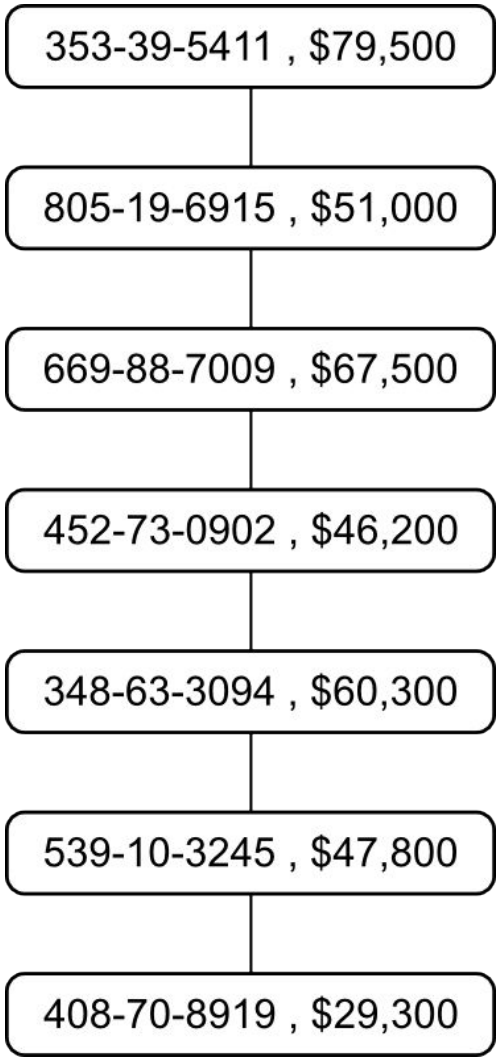
- Iterate through the list checking each key

To delete an item by key:

- Find it and then delete the pair from the list

With 7 items, looking for the last key (the "worst case") takes 7 iterations

With 300,000,000 items, the worst case takes 300,000,000 iterations

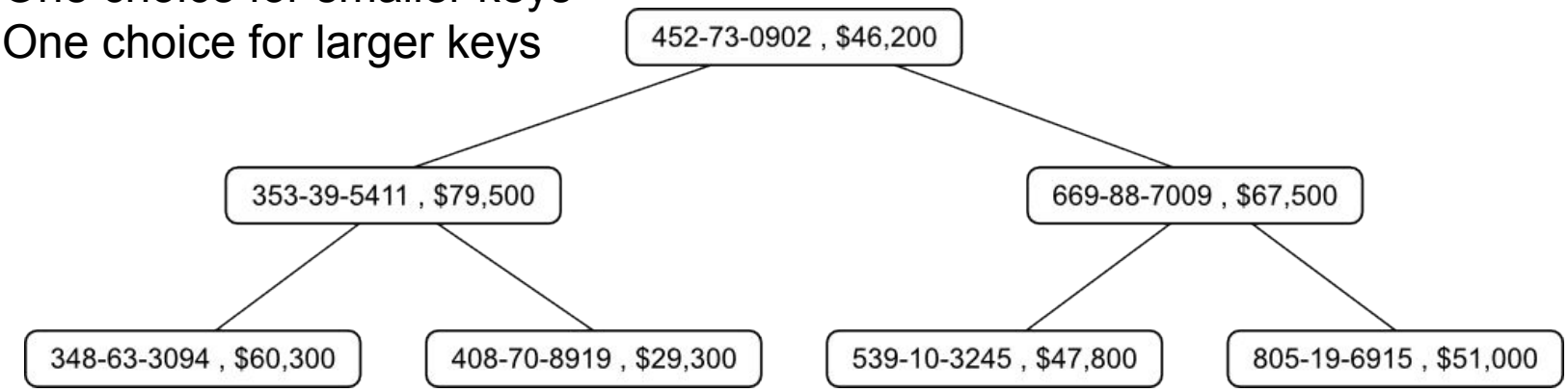


A Flavor of Something More Advanced

Dictionary Implementation 2 - A Binary Search Tree

Idea 2: Instead of one "path" through the pairs, make two "next choices" at each step of the iteration

- One choice for smaller keys
- One choice for larger keys



Worse case for 7 keys is now 3 comparisons/iterations (7 = 2^3-1)

In 4 steps could handle 15 keys (15 = 2^4-1)
In 5 steps could handle 31 keys (31 = 2^5-1)
…
In 29 steps could handle 536,870,911 keys (2^{29}-1) - enough for all 314 million U.S. citizens

Using a list would take over 18 million times longer!

Summary

Big take-aways:

1. *Abstract Data Types allow you to focus on using your data without worrying about how it is organized.*
2. *Data Structures describe how data is organized, and can make a huge difference on how efficiently you can use it.*

Other things to remember from this lecture:

- Lists are the most fundamental data structure - understand lists!
- Binary Search Trees can locate information fast - know the basic idea!

If you study more computer science:

- You'll learn about a variety of generally useful ways to think about data (ADTs)
- You'll learn about many advanced ways to organize data (data structures)
- You'll learn how to analyze, discuss, and compare efficiency of alternatives