Data Structures(CS- 213)

Mohammad Asad Abbasi

Lecture 1: Introduction

Structure of the Course

- Lectures / Lab/ Class participation
- Assignments (programming)
- Quizzes
- Midterm examination
- Final examination

Grading

Assignments	5%
Quizzes	5%
Lab	10%
Midterm Exam	30%
Final Exam	50%
Total	100

Readings

- Readings from the required text are assigned for each lecture, read them in advance.
- Course book :**Data Structures by Seymour Lipschutz. (International Edition- Schaum's Outline Series.)**
- The book contains self-test exercises in each section
- Work these exercises (especially if you are new to the material)

- But I will use material from other books and research papers, so the ultimate source should be my lectures.

Syllabus

- Logic Building, Flowcharting and Pseudo code development
- Introduction to Abstract Data Types, basic terminology Data structure operations, algorithms, space and time complexity Review of basic mathematical and programming background
- Arrays: one D, 2D and 3D, Traversal, insertion and deletion,
- Representation in memory, Row Major Column Major and C++ representation Records and Structures
- Linked Lists, Linked List Operations
- Stacks and Queues
- Priority Queues through Heaps

Syllabus

- Binary Tree, Linked Representation of Binary Trees, Insertion and Deletion, Traversal of Binary Trees (In order, Post order and Pre Order) Post Fix and Infix notations
- Binary Search Trees, Insertion and Deletion
- Graphs, Graph representation,
- Graph traversal algorithms, Searching algorithms
- Searching, Linear Search, Binary Search,
- Sorting Algorithms

Smart devices

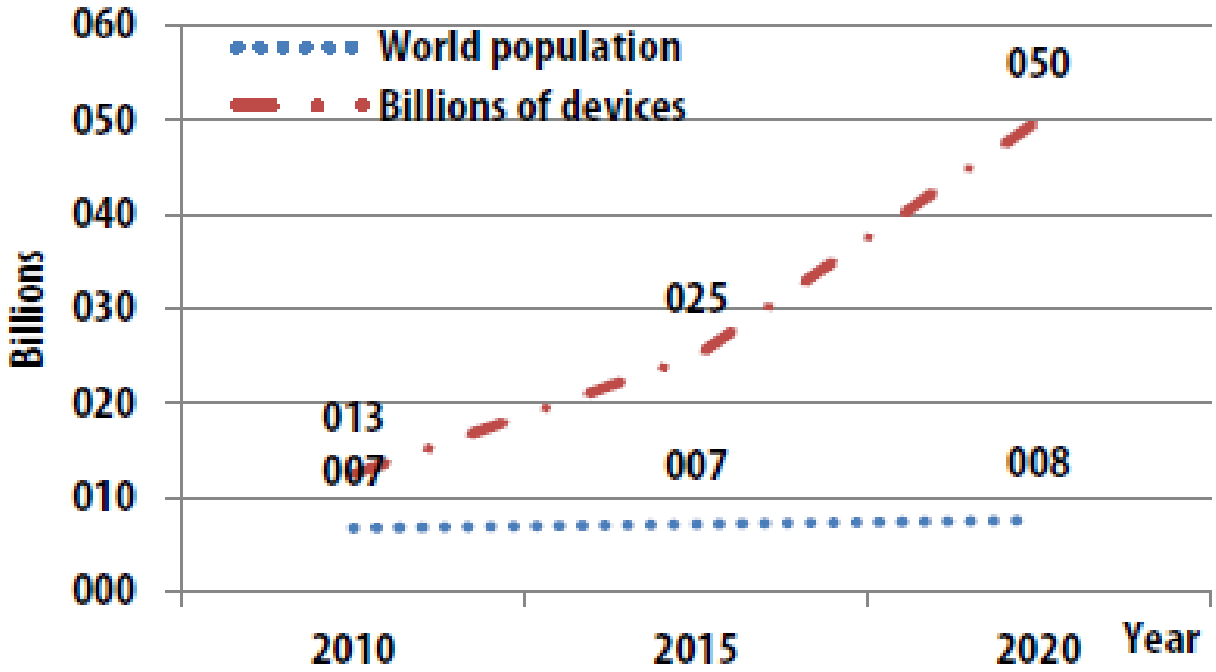
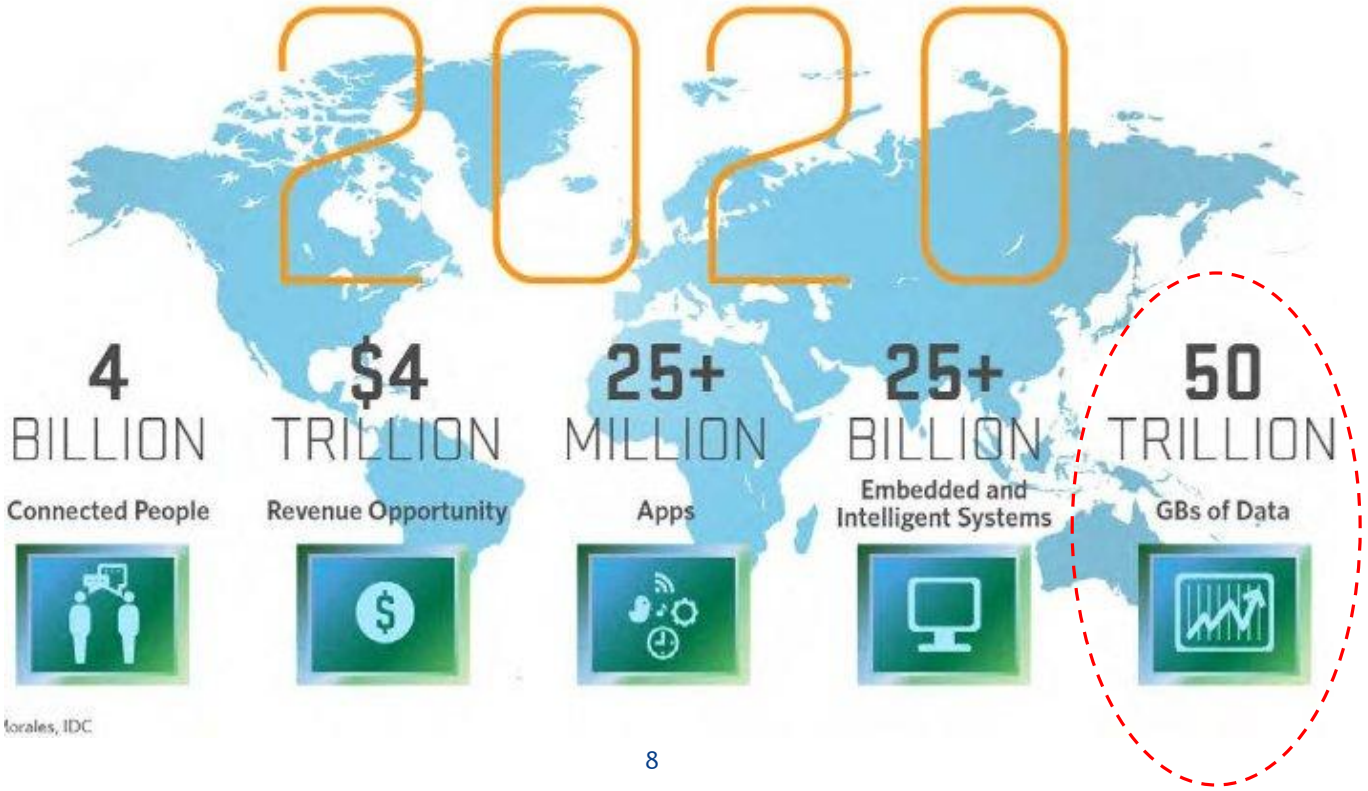


Figure 1. IoT devices and the future evolution

Smart devices



Introduction to Data Structures

- ***Data***
  - Data are values or a set of values
  - Data item refers to single unit of values
- **Data item**
  - Group item :
    - Data item that can be subdivided into sub item.
    - Ex Name : First Name, Middle initial and Last Name
  - Elementary item:
    - Data item that can not be sub divided into sub item
    - Ex : card number / Bank Pass Book Number is treated as single item
- Collection of data are frequently organized into a hierarchy of **fields, records and files**

Data Structures

- **Field ,Record and File**
- **Field**
  - is a single elementary unit of information representing an attribute of an entity
- **Record**
  - is the collection of field values of a given entity
- **File**
  - is the collection of records of the entities in a given entity set

Name	Age	Sex	Roll Number	Branch
A	17	M	109cs0132	CSE
B	18	M	109ee1234	EE
C	19	F	109ce0012	CE
D	20	F	108mm0132	MM

Data Structures

- Entity
  - Something that has certain attributes or properties which may be assigned values
  - Values may be numeric or non-numeric
- Ex The employee of an organization
  - **Attributes** Name Age Sex Employee Code
  - **Values** John 33 M 3472

Data Structures

- **Entity Set**

- Entity with similar attributes (e. g all employees of an organization) form an **entity set**

- Each attribute of an entity set has a **range of values** [the set of possible values that could be assigned to the particular attribute]

- **Information**: Data with given attribute or processed data

Introduction to Data Structures

- **Record**
- Record may be of fix and variable length
- Fixed Length Record
  - All records contain the same amount of data items with the same amount of space assigned to each data item
- Variable Length Record
  - File records may contain different lengths.
  - e.g student record usually have variable lengths .since different students take different number of courses
  - Usually variable length records have a minimum and a maximum length

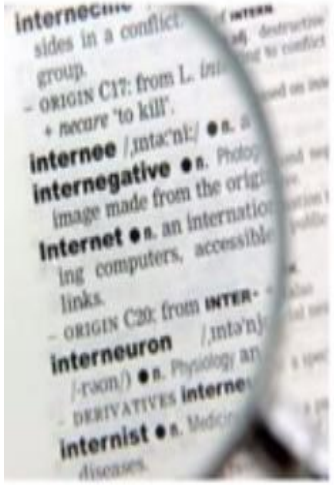
Introduction to Data Structures

- Data is a set of elementary items.
- How do we organize information so that we can find, update, add and delete portions of it efficiently?
- "The data structures deal with the study of how the data is **organized** in the memory, how efficiently it can be **retrieved** and **manipulated** and the possible ways in which different data items are logically related".

Introduction to Data Structures

It's an agreement about:

- how to store a collection of objects in memory
- What operations we can perform on that data
- The algorithms for those operations
- How time and space efficient those algorithms are.



English Dictionary

City map

ABC Hardware

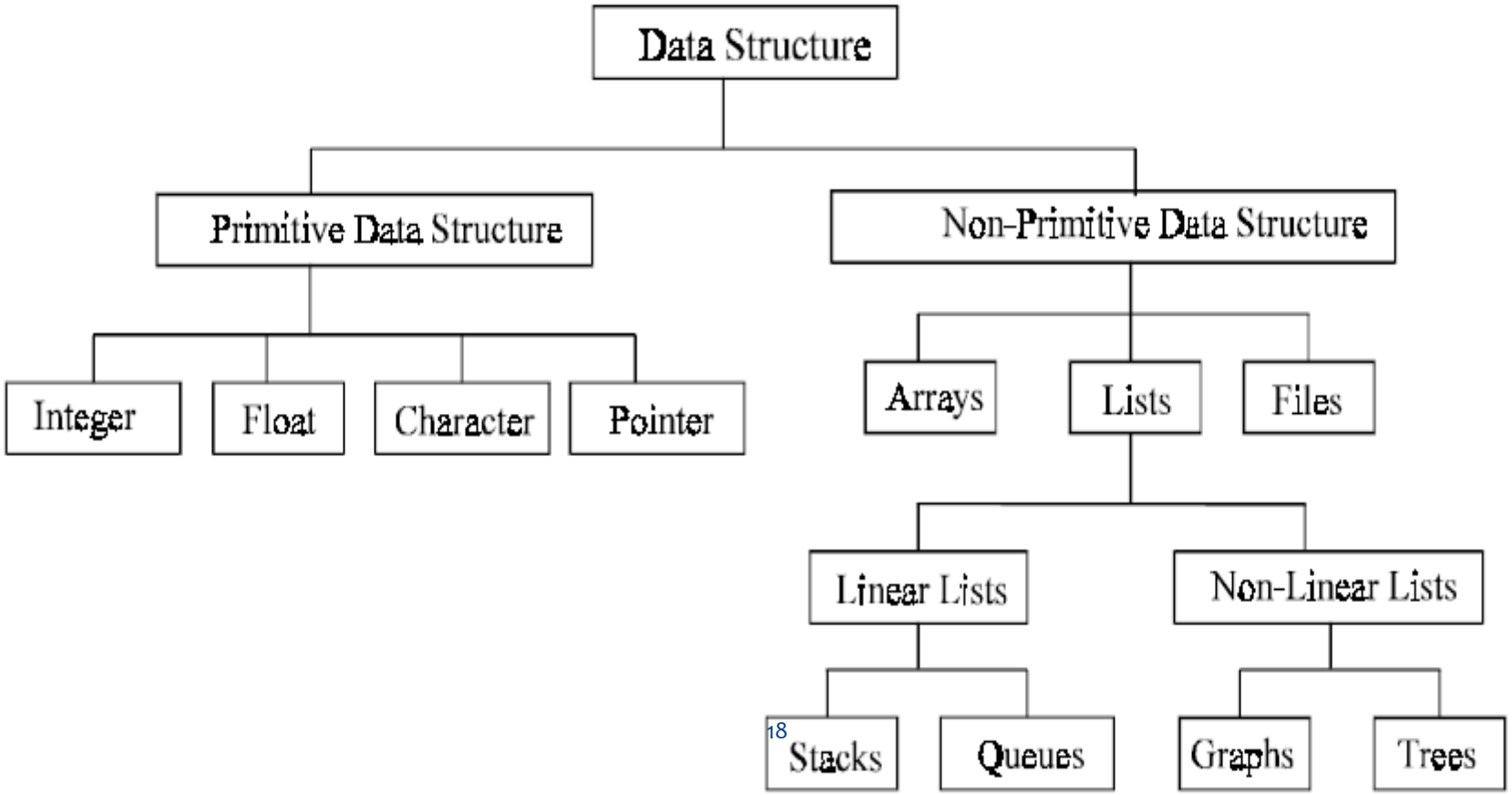
Cash Book - 03/01/2013 to 03/31/2013

S. no.	Date	Particulars	Debit	Credit
1	03/01/2013	Opening balance		50000
2	03/02/2013	Transport bill	2000	
3	03/07/2013	Goods sales		1500
4	03/08/2013	Bank Loan		5000
5	03/15/2013	Goods sales		1000
6	03/17/2013	Electiricty bill	1200	
7	03/21/2013	Good sales		1200
8	03/25/2013	Hardware purchase	500	
9	03/29/2013	Employee salary	20000	
10	03/31/2013	Closing Balance	35000	
		Total	58,700	58,700

Data Structures

- The way in which the data is organized affects the performance of a program for different tasks.
- Computer programmers decide which data structures to use based on the **nature of the data** and the **processes** that need to be performed on that data.
- They can be classified as:
  - Primitive data structures
  - Non primitive data structure.

Classifications of Data Structures



Classifications of Data Structures

- **Primitive data structure**
  - Basic data types that are available in most of the programming languages. The primitive data types are used to represent single values.
  - These are data structures that can be manipulated directly by machine instructions.
  - Primitive types are also known as built-in types or basic types.
  - In C language, the different primitive data structures are int, float, char, double.

- **Non primitive data structures**
  - The data types that are derived from primary data types are known as non-Primitive data types. These data types are used to store group of values.
  - These are data structures that can not be manipulated directly by machine instructions. Arrays, linked lists, files etc., are some of non-primitive data structures and are classified into *linear data structures* and *non-linear data structures*.

Linear and non- linear data structures

- The data structures that show the relationship of logical adjacency between the elements are called linear data structures.
- Otherwise, they are called non-linear data structures.
- Different linear data structures are stacks, queues, linear linked lists such as singly linked list, doubly linked linear lists etc.
- Trees, graphs and files are non-linear data structures.

Common Data Structures

- Array
- Stack
- Queue
- Linked List
- Tree
- Heap
- Hash Table
- Priority Queue

Functions of Data Structures

- Add
  - Index
  - Key
  - Position
  - Priority
- Get
- Change
- Delete

Data Structure Example Applications

1. How does Google quickly find web pages that contain a search term?

2. What's the fastest way to broadcast a message to a network of computers?

3. How can a subsequence of DNA be quickly found within the genome?

4. How does your operating system track which memory (disk or RAM) is free?

5. In the game Half-Life, how can the computer determine which parts of the scene are visible?

Suppose You're Google Maps…

- You want to store data about cities (location, elevation, population)…

- What kind of operations should your data structure(s) support?

Operations to support the following scenarios…

- Finding addresses on map?
  - Lookup city by name…
- Mobile iPhone user?
  - Find nearest point to me…
- Car GPS system?
  - Calculate shortest-path between cities…
  - Show cities within a given window…
- Political revolution?
  - Insert, delete, rename cities

Data Organizing Principles

- **Ordering**
  - Put keys into some order so that we know something about where each key is, relative to the other keys.
  - Phone books are easier to search because they are alphabetized.

- **Linking**
  - Add pointers to each record so that we can find related records quickly.
  - E.g. The index in the back of book provides links from words to the pages on which they appear.

- **Partitioning**
  - Divide the records into 2 or more groups, each group sharing a particular property.
  - E.g. Multi-volume encyclopedias (Aa-Be, W-Z)
  - E.g. Folders on your hard drive

Ordering

Pheasant,	10
Grouse,	89
Quail,	55
Pelican,	3
Partridge,	32
Duck,	18
Woodpecker,	50
Robin,	89
Cardinal,	102
Eagle,	43
Chicken,	7
Pigeon,	201
Swan,	57
Loon,	213
Turkey,	99
Albatross,	0
Ptarmigan,	22
Finch,	38
Bluejay,	24
Heron,	70
Egret,	88
Goose,	67

Sequential Search – O(n)

Albatross,	0	
Bluejay,	24	
Cardinal,	102	
Chicken,	7	
Duck,	18	← (2)
Eagle,	43	
Egret,	88	← (3)
Finch,	38	
Goose,	67	← (4)
Grouse,	89	
Heron,	70	← (1)
Loon,	213	
Partridge,	32	
Pelican,	3	
Pheasant,	10	
Pigeon,	201	
Ptarmigan,	22	
Quail,	55	
Robin,	89	
Swan,	57	
Turkey,	99	
Woodpecker,	50	

Search for "Goose"

Binary Search O(log n)

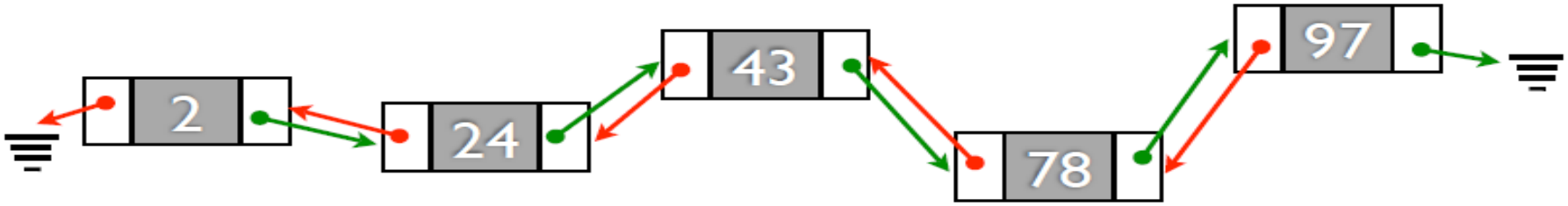
Every step discards half the remaining entries:

$$n / 2^k = 1$$

$$2^k = n$$

$$k = \log n$$

Linking



- Records located any where in memory
- Green pointers give "next" element
- Red pointers give "previous" element
- Insertion & deletion easy if you have a pointer to the middle of the list

- Don't have to know size of data at start
- Pointers let us express relationships between pieces of information.

Partitioning

- Ordering implicitly gives a partitioning based on the "<" relation.
- Partitioning usually combined with linking to point to the two halves.
- Prototypical example is the Binary Search Tree: