CSE408
Fundamentals of Data Structure

Lecture #2

Fundamental data structures

- array
- linked list
- string
- stack
- queue
- priority queue/heap
- graph
- tree and binary tree
- dictionary

Linear Data Structures

- Arrays
  - A sequence of n items of the same data type that are stored contiguously in computer memory and made accessible by specifying a value of the array's index.
- Linked List
  - A sequence of zero or more nodes each containing two kinds of information: some data and one or more links called pointers to other nodes of the linked list.
  - Singly linked list (next pointer)
  - Doubly linked list (next + previous pointers)

- Arrays
  - fixed length (need preliminary reservation of memory)
  - contiguous memory locations
  - direct access
  - Insert/delete
- Linked Lists
  - dynamic length
  - arbitrary memory locations
  - access by following links
  - Insert/delete

Stacks and Queues

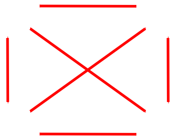
- Stacks
  - A stack of plates
    - insertion/deletion can be done only at the top.
    - LIFO
  - Two operations (push and pop)
- Queues
  - A queue of customers waiting for services
    - Insertion/enqueue from the rear and deletion/dequeue from the front.
    - FIFO
  - Two operations (enqueue and dequeue)

Graphs

Formal definition

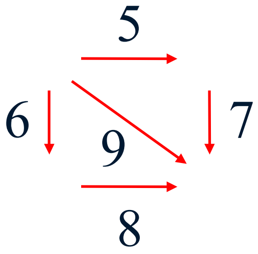
- A graph *G* = <*V*, *E*> is defined by a pair of two sets: a finite set V of items called vertices and a set E of vertex pairs called edges.

- Undirected and directed graphs (digraphs).
- What's the maximum number of edges in an undirected graph with |V| vertices?
- Complete, dense, and sparse graphs
  - A graph with every pair of its vertices connected by an edge is called complete, $K_{|V|}$
  - Dense graph is a graph in which the number of edges is close to the maximal number of edges. Sparse graph is a graph in which the number of edges is close to the minimal number of edges.



Weighted Graphs

- Weighted graphs
  - Graphs or digraphs with numbers assigned to the edges.

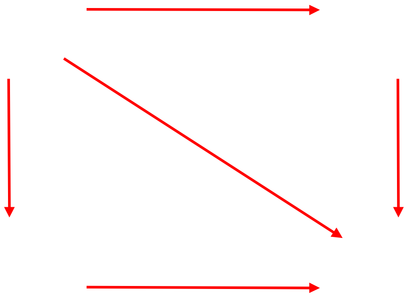


Graph Properties -- Paths and Connectivity

- Paths
  - A path from vertex u to v of a graph G is defined as a sequence of adjacent (connected by an edge) vertices that starts with u and ends with v.
  - Simple paths: All edges of a path are distinct.
  - Path lengths: the number of edges, or the number of vertices – 1.
- Connected graphs
  - A graph is said to be connected if for every pair of its vertices u and v there is a path from u to v.
- Connected component
  - The maximum connected subgraph of a given graph.

Graph Properties -- Acyclicity

- Cycle
  - A simple path of a positive length that starts and ends a the same vertex.
- Acyclic graph
  - A graph without cycles
  - DAG (Directed Acyclic Graph)



Trees

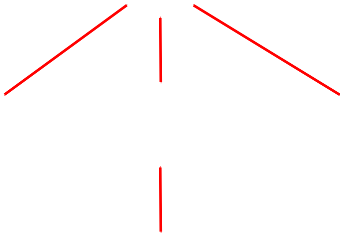
- Trees
  - A tree (or free tree) is a connected acyclic graph.
  - Forest: a graph that has no cycles but is not necessarily connected.
- Properties of trees
  - For every two vertices in a tree there always exists exactly one simple path from one of these vertices to the other. Why?
    - Rooted trees: The above property makes it possible to select an arbitrary vertex in a free tree and consider it as the root of the so called rooted tree.

Rooted Trees (I)

- Ancestors
  - For any vertex *v* in a tree *T*, all the vertices on the simple path from the root to that vertex are called ancestors.
- Descendants
  - All the vertices for which a vertex *v* is an ancestor are said to be descendants of *v*.
- Parent, child and siblings
  - If *(u, v)* is the last edge of the simple path from the root to vertex *v*, *u* is said to be the parent of *v* and *v* is called a child of *u*.
  - Vertices that have the same parent are called siblings.
- Leaves
  - A vertex without children is called a leaf.
- Subtree
  - A vertex *v* with all its descendants is called the subtree of *T* rooted at *v*.

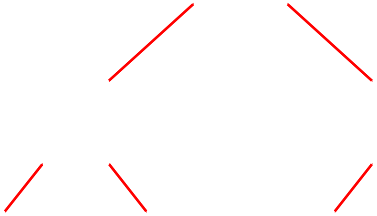
Rooted Trees (II)

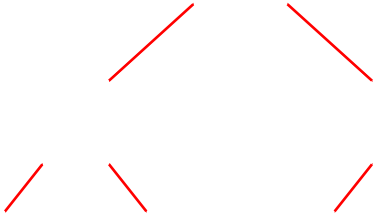
- Depth of a vertex
  - The length of the simple path from the root to the vertex.
- Height of a tree
  - The length of the **longest simple path** from the root to a leaf.



Ordered Trees

- Ordered trees
  - An ordered tree is a rooted tree in which all the children of each vertex are ordered.
- Binary trees
  - A binary tree is an ordered tree in which every vertex has no more than two children and each children is designated s either a left child or a right child of its parent.
- Binary search trees
  - Each vertex is assigned a number.
  - A number assigned to each parental vertex is larger than all the numbers in its left subtree and smaller than all the numbers in its right subtree.





Thank You !!!