Exam 2014, questions and answers

Data Structures and Algorithms (University of Pretoria)

Question 1 /Vraag 1 ..... (3 marks)

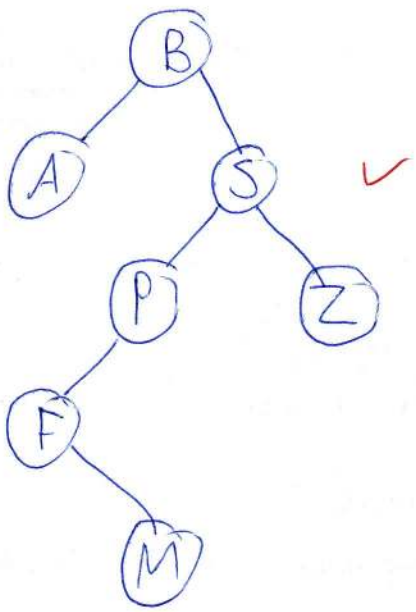
1.1 Beskou die `treap` struktuur in **figuur 1**. Wat sal die prioriteit van `F` wees indien die struktuur met 'n min-hoop as 'n skikking geïmplementeer is? (1)
Consider the ***treap*** *structure in* ***figure 1****. What would the priority of* `F` *be if this structure was implemented with a min-heap as an array?*

6 ✓

1.2 Aanvaar dat die `treap` in **figuur 1** as 'n maks-hoop geïmplementeer is waar die elemente die volgende prioriteite het: (2)
Assume that the ***treap*** *in* ***figure 1*** *is implemented as a max-heap where the elements have the following priorities:*

`E:50, B:31, S:30, A:15, P:12, Z:11, F:7, M:1`

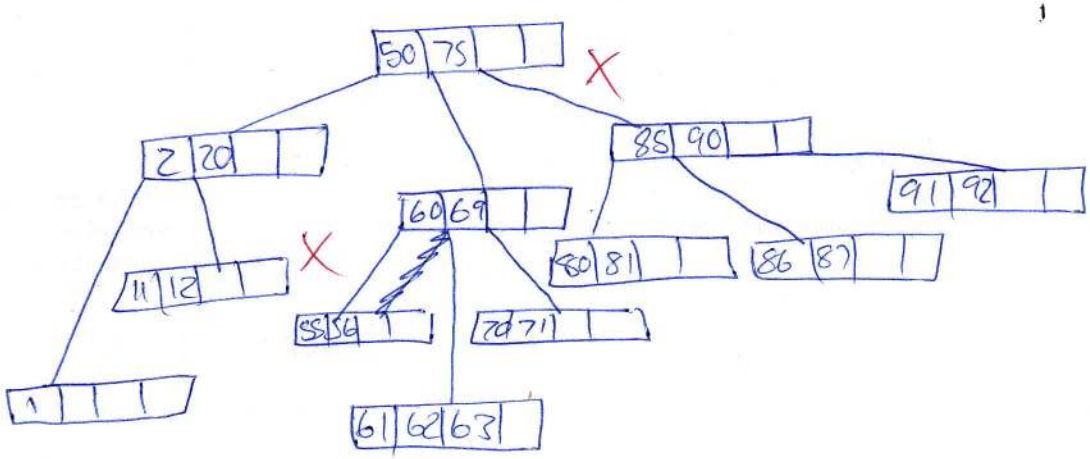
Teken die finale `treap` nadat die element `E` verwyder is.
Draw the final ***treap*** *after the element* `E` *has been removed.*



✓

Question 2 /Vraag 2 ..... (12 marks)

2.1 Beskou die `B-boom` in `figuur 2`. Maak gebruik van die direkte voorganger en verwyder die sleutel 10 uit hierdie boom. Teken die finale boom nadat die voorgenoemde verwydering plaasgevind suksesvol het. (3)
Consider the `B-tree` *in* `figure 2`*. Use the direct predecessor and delete the key 10 from this tree. Draw the final tree after the aforementioned delete has successfully taken place.*



2.2 Beskou die volgende ontbrekende `BTreeNode` klas. Objekte van hierdie klas is bedoel om as 'n nodus in 'n B-boom gebruik te word: (4)
Consider the following partial `BTreeNode` *class. Objects of this class are meant to be used as nodes in a B-tree:*

```
public class BTreeNode<T>
{
        //Constructors, initialization and additional methods omitted.

        int m; // The order of the tree
        int numKeys; //The number of keys
        public Comparable<T> keys[]; //The keys
        public BTreeNode<T> children[]; //The children.
}
```

Skryf minimum kode vir 'n rekursiewe metode genaamd `countNodes` om die aantal nodusse in 'n B-boom te tel.
Write minimal code for a recursive method named `countNodes` *to count the number nodes in a B-tree.*

2.3 Wanneer die wortel nodus in 'n B*-boom split, sal daar nie genoeg sleutels wees om te verseker dat hierdie nodus en die nuwe sibbe almal twee-derdes vol sal wees nie. Stel 'n oplossing vir hierdie scenario voor. (2
When the root node in a B-trees splits, there won't be enough keys to ensure both it and its new siblings will be at least two-thirds full. Suggest a solution to this scenario.*

A new node is created and the keys are distributed between the nodes. X

0

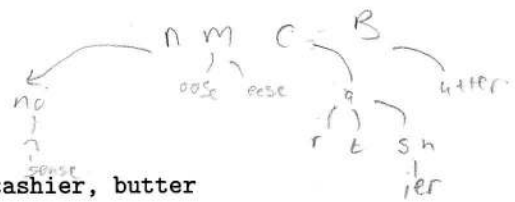
1

2.4 Beskou die Bit-tree blaarnodus in **figuur 3**. Skryf volgorde van die rekords (slegs die karakters/sleutels) soos hulle oorweeg sal word in die soek na die rekord `Z`. (1
*Consider the Bit-tree leaf node in **figure 3**. Write down the order in which records (only the characters/keys) will be considered in the search for the record `Z`*

0

ZLBCMA X

2.5 Aanvaar 'n trie struktuur wat die volgende woorde bevat:
Assume a trie structure containing the following words:



`no, non, nonsense, moose, meese, car, cat, cash, cashier, butter`

Elke interne nodus bevat die "einde-van-woord" karakter en slegs die karakters wat nodig is alfabeties gerangskik. Antwoord die volgende:
Each internal node contains the "end-of-word" character and only the necessary characters arranged alphabetically. Answer the following:

a) Wat is die hoogte van hierdie trie? (1
What is the height of this trie?

0

3 X

b) Hoeveel interne nodusse is daar op die pad na die woord `cashier`? (1
How may internal nodes are there on the path to the word `cashier`?

3 X

0

Question 3 /Vraag 3 ..... (40 marks)

BELANGRIK: Waar daar 'n keuse is tussen punte om volgende te verwerk, kies hulle **alfabeties**.
IMPORTANT: *Wherever there is a choice among vertices to be processed next, choose them* ***alphabetically****.*

3.1 Aanvaar 'n pseudografiek G met 10 000 lyne. Wat is die minimum aantal punte wat G mag hê. (1
Assume a pseudo graph G with 10 000 edges. Wat is the minimum number of vertices that G may have?

3.2 Aanvaar die volgende beskrywing van die grafiek G: Dit is enkelvoudig, ongerig, samehangend, bevat geen siklusse nie en het 500 lyne. Hoeveel punte het G? (1
Assume the following description of the graph G: It is simple, undirected, connected, contains no cycles and has 500 edges. How many vertices does G have?

3.3 Beskou die grafiek in **figuur 4** en antwoord die volgende:
Consider the graph in ***figure 4*** *and answer the following:*

a) Gee die volgorde waarin punte besoek sal word indien breedte eerste deurstapping op die grafiek toegepas word. (2
Give the order in which vertices will be visited if breadth first search was performed.

A D G H Z F B M J C ✓

b) Gee die volgorde waarin punte besoek sal word indien diepte eerste deurstapping op die grafiek toegepas word. (2
Give the order in which vertices will be visited if depth first search was performed.

~~A D G H Z F B M J C~~ A D H G Z F B C J M ✓

c) Hoe kan die WFI algoritme aangepas en dan gebruik word om te bepaal of daar siklusse in 'n grafiek bestaan? (2
How can the WFI algorithm be modified and then used to determine if there are cycles in a graph?

0.5

If the diagonal is initialized to 2 and not to zero,) and then ...?

d) Pas Dijkstra se kortste pad algoritme toe met die begin punt `A` en vul die afstande vir die punte in die volgende tabel: (10
Apply Dijkstra's shortest path algorithm on this graph with starting vertex `A` and fill in the distances for the vertices in the following table:

Vertex	Distance from A
A	0
B	
C	
D	3
F	
G	6
H	23
J	
M	
Z	8

9

e) Pas die `strongDFS` algoritme toe op die grafiek en voltooi die volgende tabel deur die waardes van `pred` vir elk van die gelyste punte neer te skryf: (10
Perform the `strongDFS` algorithm on the graph and complete the following table by filling in the values for `pred` for each of the listed vertices:

Vertex	Pred
A	
B	
C	8
D	
F	
G	
H	
J	
M	
Z	

5

3.4 Beskou die grafiek in **figuur 4** en antwoord die volgende:
*Consider the graph in **figure 4** and answer the following:*

a) Kan 'n topologiese sortering uitgevoer word op hierdie grafiek? Indien wel, gee slegs die sortering en indien nie, motiveer waarom nie. (2
Can topological sorting be applied to this graph? If your answer is yes, simply give the ordering of the vertices, otherwise motivate why not.

yes, there are no cycles.

0

b) Aanvaar die ongerigte weergawe van die grafiek moet ingekleur word met die `BrelazColoringAlgorithm`. Die beskikbare kleure word in die volgende volgorde gegee: `[rooi, groen, blou, pers, goud]`. Pas hierdie algoritme toe op die grafiek en voltooi die tabel hierdonder deur die korrekte waardes vir die versadigingsgraad (saturation degree) vir elk van die gelyste punte in te vul: (10)

Assume that the undirected version of the graph needs to be coloured using the `BrelazColoringAlgorithm`. The available colours are given in the following order: `[red, green, blue, purple, gold]`. Apply this algorithm to the graph and complete the table below by filling in the correct values for the saturation degrees for each of the vertices listed in the table:

Vertex	saturationDeg
A	red
G	green
H	green
I	red
L	blue
M	green
O	green
R	red
S	blue
T	red

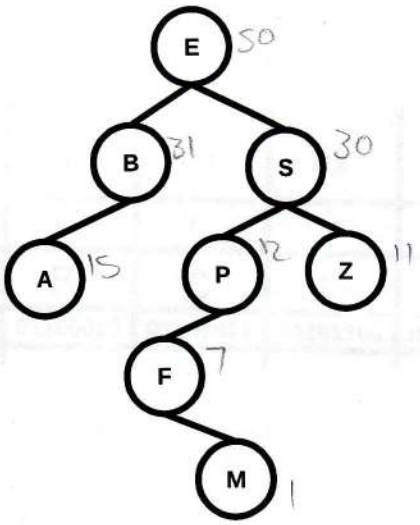


Figure 1: Treap

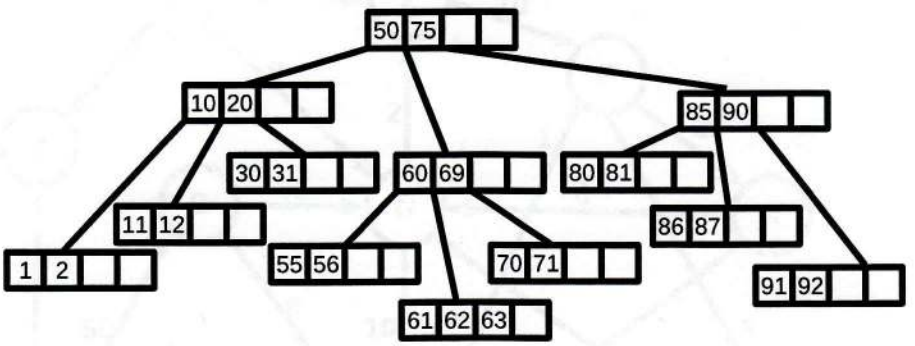


Figure 2: B-Tree

Position in leaf	i-1	i	i+1	i+2	i+3	i+4
D bits	...	6	7	4	7	3
Key	A	B	C	L	M	Z
Key code	01100001	01100010	01100011	01101100	01101101	01111010

Figure 3: Bit-tree leaf

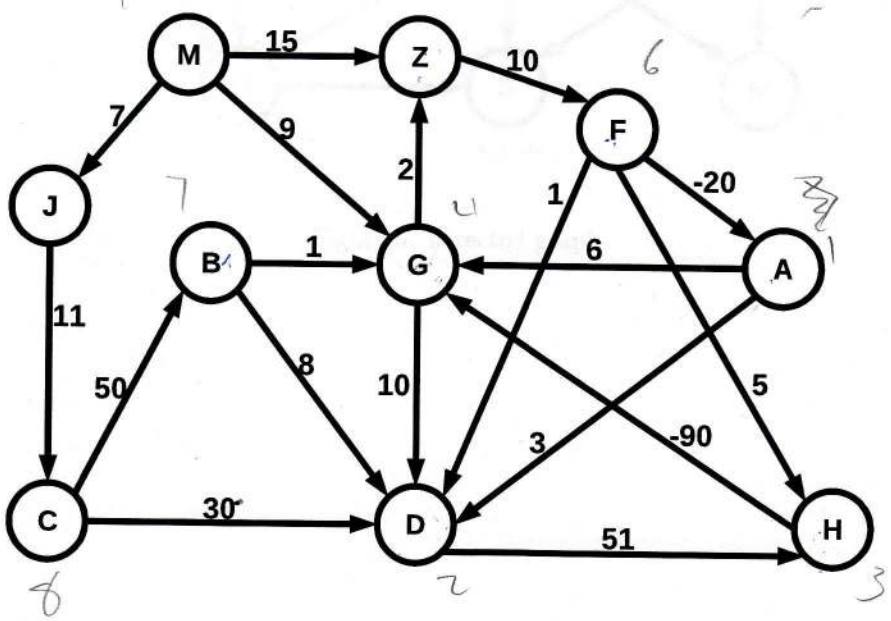


Figure 4: Directed weighted graph

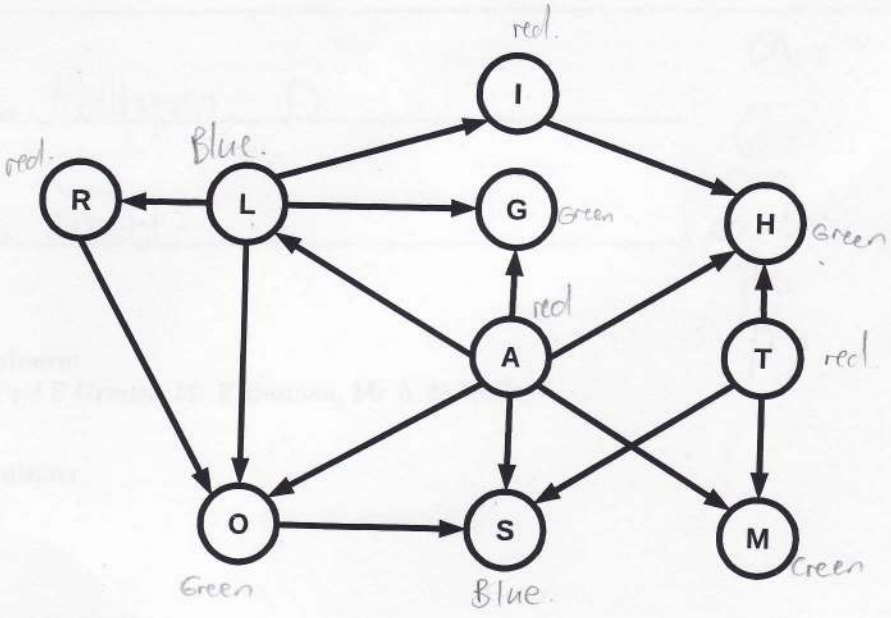


Figure 5: Directed graph