HIT220 - Assignment 2

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1 Rubric

1. This document is available https://www.overleaf.com/read/cgwdgmvhppzr
2. Submit your answers as a pdf on submission link on Learnline. **Please make sure you include the outline of the question in the sheet or it will not be marked**
3. Hand drawings can be scanned and inserted for images, but **scanned code will not be marked**
4. Marking rubric for each question:
   Marks will be awarded for accuracy, completeness, and well communicated reasoning which demonstrates your depth of understanding of the subject matter.
   Marking is done as:
   a Full marks are possible if provide working code or very explicit but succinct pseudo code (ie correct code without correct syntax)
   b Three quarter marks are possible if provide pseudo code or code that is nearly correct
   c For these marks:
      i. Half marks will be given for right answer with some comments, and for succinct code when coding required.
      ii. Half marks will be given for a clear explanation of working whether or not result is right

All questions total marks are shown.

2 Questions

The questions are annotated with the weeks' slides that are relevant

1. (2 points) Searching Stack Week 3.1
   Write the following for the method on the stack

```
def contains(stackName: Stack, search: str):
    return bool
```

   which will take a Stack and a String, and returns True if the Stack contains this string of characters in the same sequence. Return false if not found in the Stack. The elements in the Stack **redmust remain in their original order** once this method is complete.

2. (3 points) Array Class Week 3 Slides 4.1 Exercise Workshop Week 3
Implement an array as a linked list in python/java or pseudocode. Assume the data entry is hard coded, you do not enter from terminal. Your array object must include at least the methods required to define the Abstract Data Type (ADT) Array. Test your program for robustness. If using pseudo code you will need to consider odd cases, etc
Write up a summary of the big O complexity of each algorithm in your program (using counting techniques from Week 1 Workshop). In each case, write a sentence to explain the complexity. (You do not need to give calculations or formal proof here)

3. (3 points) P-NP Week 5.2
Answer the following questions on the complexity classes P and NP. Justify your answers

   a Is P $\subseteq$ NP? If so can we say P=NP?

   b A problem Q is in P and there is a polynomial-time reduction from Q to Q $'$.
   What can we say about Q $'$?
   Is Q $' \in$ P?
   Is Q $' \in$ NP?

   c Let Q be a problem defined as follows:
   Input: a set of numbers A $= a_1, a_2, ..., a_N$ and a number x
   Output: 1 if and only if there are two values $a_i, a_k \in A$ such that $a_i + a_k = x$.
   Is Q in NP?
   Is Q in P?
   Explain your answer.

4. (4 points) Heap Sort Week 4 Workshop Heap examples

   a Give the below array of items, show the steps you would perform to make a max heap of this array.

0	1	2	3	4	5	6	7	8	9
23	12	4	18	29	10	4	16	13	6

Table 1: Original Array

   b Describe the steps to remove the top element and re-heap.

   c What sort of application is this sort often used for?

5. (2 points) Storage Consider any structures we have discussed: Stack Queue Priority Queue Array List Dictionary MaxHeap
You wish to create a database of stars. For each star, the database will store several megabytes of metadata including images and other descriptors. Considering that your database will store billions of stars, choose the data structure that will provide the best performance.
With this data structure you should be able to find, insert, and delete stars.
Justify your choice.

6. (2 points) Matrix Week 6 Linear Algebra

   a Given an m x n matrix write the code to output the transpose of the matrices as an n x m matrix
   First consider how to store a matrix in your algorithm

   b Given an m x n matrix write the code to output the diagonal elements of the matrix as a vector.

c Given an n x n matrix where each of the rows and columns are sorted in ascending order, return the kth largest element in the matrix.
An example would be:

$$\begin{vmatrix} 2 & 5 & 8 \\ 3 & 9 & 13 \\ 12 & 14 & 15 \end{vmatrix}$$

The 5th element is 9 as the elements of the matrix are [2,3,5,8,9,12,13,14,15].

7. (4 points) Search Trees Week 4.3 Trees extend from binary to b-nary tree
The insertion of data into a tree can be done in various ways to ensure the height of the tree is minimum, and that searching the tree for an item is not more than $O(log_b n)$ where b is the number of children on a node. Assume children are sorted left to right.

   a Draw separate trees with 8 nodes that include one of: balanced; binary tree; neither of these.

   b Write in pseudo code or code to traverse the tree and verify if it is balanced and/or binary. First consider how you will represent the edges and nodes as data in your program and used this in your code.

   c Then consider which traversal method you will use (pre-order, post-order or in-order), and name it in your code.

   d Assume your tree is binary. Now:

      (a) Provide pseudo code or code to carry out a breadth first search of a binary tree and explain each step (Workshop Week 5).

      (b) What is the complexity of the search?

      (c) What data structure did you use for the storage of nodes as your run the search above?

8. (3 points) Optimizing access Week 6 Networks Storage of Matrix

   a We are analysing croc capture data to assess ways to predict the location of crocodiles at any time. The real data is in the file supplied
   NT Crocodile Capture.xls, but we have created more location based data to analyse the ideas we are considering

   b See the NT management areas map here Data Map

   c Prepare your data for Assignment 3. You will need to put the data from the map supplied into a data structure suitable for searching and sorting
   You will enter each data point (sighting) with is grid location to the half space eg

```
1 3.5 8.5
2 3.5 7.5
etc
```

   Then you will calculate an estimate of distance between each pair of points along the routes provided (Linear ALgebra). These are the routes that we believe the crocs are taking. Note one unit is 10km
   If coding provide an image of the graph you have created, if using pseudo code, provide an image traced from the map provided of just the routes, plus your calculations
   Note if route is by water or by land and store this too (consider data storage structure).

   d Explain how you have stored the data and why you used this.

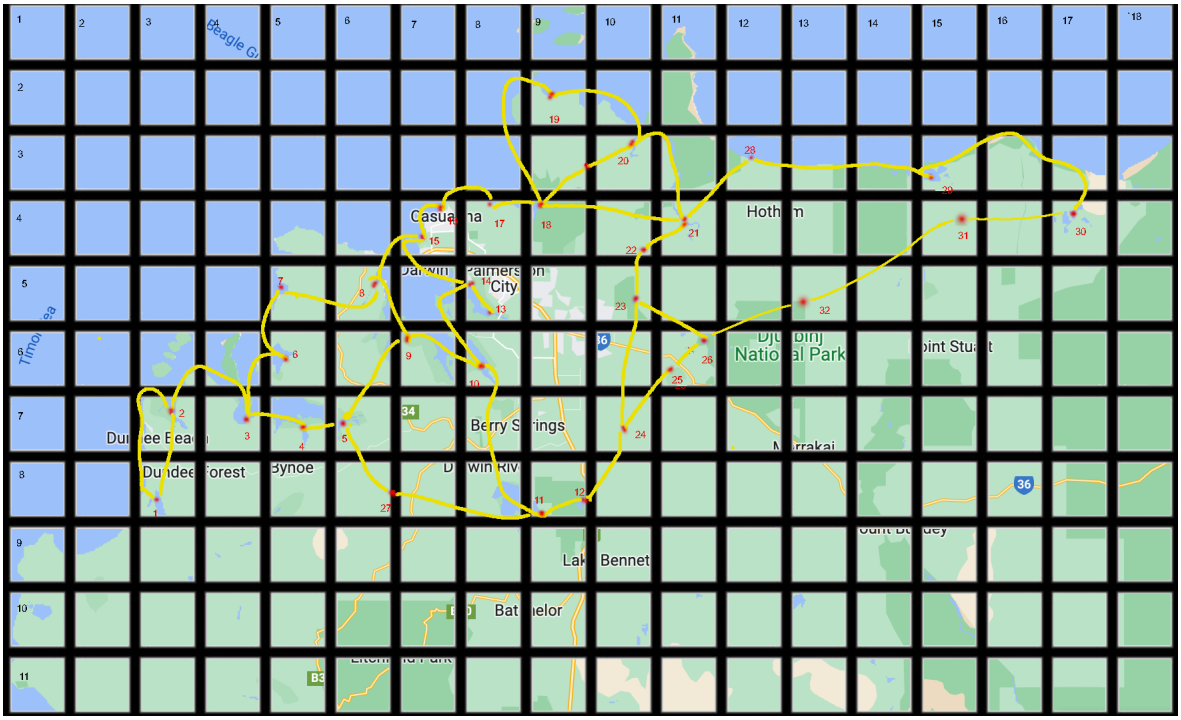

Figure 1: Croc Sightings - exaggerated

e Write a function/pseudo code to give a list of all the paths and their distance between any two points from the data provided.

9. (3 points) Map colouring Week 5 Workshop k-colourable

a Draw a graph of the regions on the map including dividing regions left and right or above and below the highways as marked.
That is enter a vertex for every region and an edge joining those regions with a common boundary

b Store the graph of this map in code (ie hard code your data)

c Write an algorithm in code or pseudo code to find if any such map is 3-colourable

d Use your code to advise each region where they can get extra fire trucks from, in an emergency. Assume the trucks are on average based in the centre of each region during fire season. Rough estimate of distance between region centres is sufficient.
eg

```
Macdonnell_West to Macdonnell_East = 3 units
Central_Desert_West to Central_Desert_East = 5 units
Macdonnell_West to Central_Desert_East = 4 units
```

10. (4 points) Advanced: Optimize Network Week 6 Distributed Systems Minimising distance (not coded)
There is zero marks for a coded answer to this question
We do not expect this to be the optimum solution, we are asking you to consider the problem and come close to the optimum process

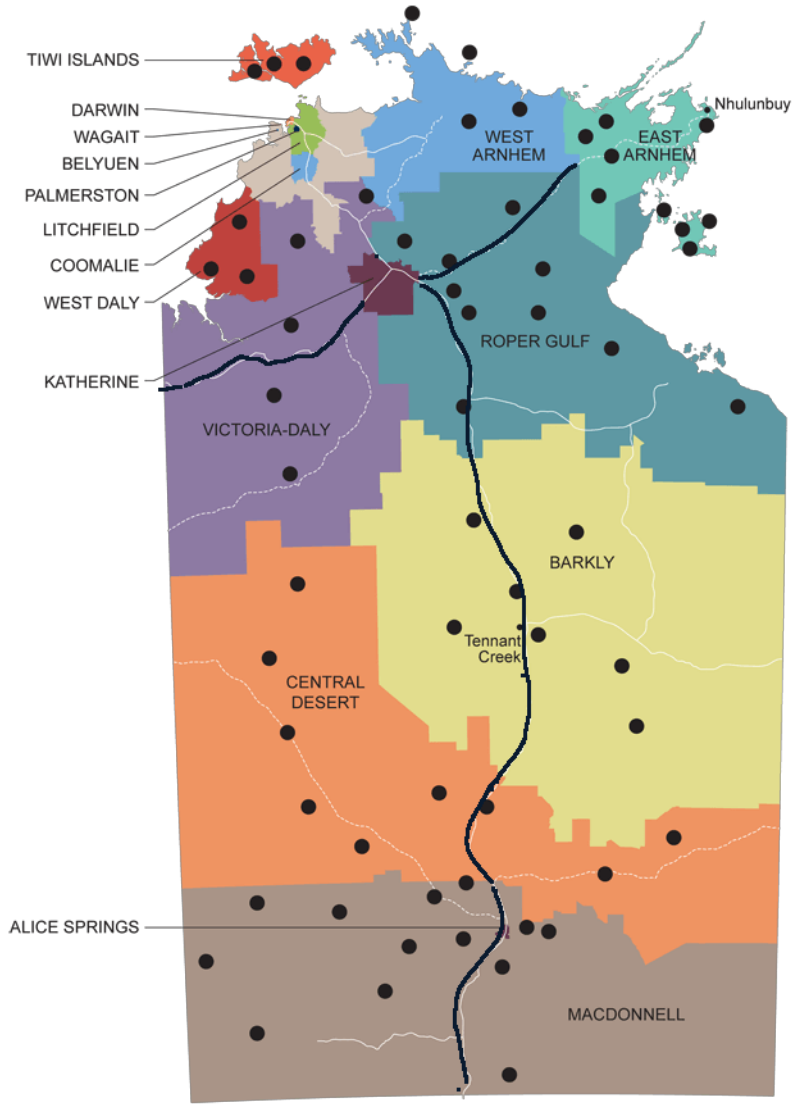

Figure 2: Bush Fire regions

There are n houses in a village and we want to supply internet to each house by locating modems at each house or providing cable to another house which has a modem (this may be wifi/microwave link if long distance).
However the modems have a high price and the size varies due to different usage at that house and the cost of laying of cable varies between houses due to distance.
Once a house has a modem with router, other houses may be connected to this
Describe in pseudo code an algorithm that will have:

1. Input: the cost (size) of the modem for each house and the cost of cable between any pair of houses as a list of lists $[house_1, house_2, cost]$ and provide the optimum construction.

2. Output: is a list length n where $list = [\{house_i : [modem : boolean, houseLinkedTo : int, cost : int]\}]$ plus total cost.