Practical Task 4.2

(High Distinction Task)

Submission deadline: 11:59 pm Sunday, April 28
Discussion deadline: 11:59 pm Friday, May 26

Task Objective

The aim of this task is to write an industry proposal for a solution to a complex problem by researching algorithms not previously discussed in the unit.

Your Background

You are employed by XYZ Developments as a Software Engineer. During your first week your project manager has been called away to oversee another project in Europe for a few weeks and so has asked you to write a project proposal that is due before she is expected to return. Unfortunately, she has only provided you with a link to the Government's call for proposal and has left limited details about how to approach the task. Below is text from the State Government's call for proposals.

Government's Call for Project Proposals: Smart Evacuation

The 2019-2020 bushfire season in the state of Victoria, Australia, was an unprecedented event in both its intensity and devastation with 34 fatalities and a huge loss of land and wildlife[1]. However, it follows a trend of increasing fire activity over the past two decades[2]. To this end the State Government[3] is endeavouring to introduce strategies to both reduce the risk of bushfires, as well as using technology to reduce the risk to residents when a bush fire occurs.

The Smart Evacuation project aims to develop an app for residents to use to optimise the evacuation of residence from high-risk areas. The aim of the app is that residents with the app will, not just receive a notification of the need to evacuate (in the way the current alert apps work), but will also be provided specific instructions indicating when to leave and what roads to take to evacuate safely. This advice will be based on:

- the current location and movement of fires in the area;
- how many other people in the area are trying to evacuate at the same time; and,
- the capacity and condition of the roads to handle the required traffic.

The State Government is requesting proposals for the development of a prototype app to be implemented for the rural Victorian Town of Buninyong. Buninyong is Victoria's first inland town settled in 1838 and was officially recognised in 1851. This town, located to the south of Ballarat, is recognised as the original location gold was found that gave rise to the 1850's Gold Rush in Ballarat and Western Victoria. Today, Buninyong has a population of nearly 4000 and is surrounded by farmland and bush. As a historic tourist town and the home of the Cycling Australian Road National Championships[4] the town's temporary population can grow to well over 10,000 people.

Almost every year the town is threatened by bush fires. The town has four roads in and out of the town (North, South, East and West). Each of these are single lane roads with limited capacity to handle significant traffic. Additionally, each of these roads travel through farm and bushland that are at risk of fast-moving

[1] https://guides.slv.vic.gov.au/bushfires/2019
[2] https://www.anu.edu.au/news/all-news/study-shows-wildfires-increasing-in-size-and-frequency
[3] The remainder of this text is fictitious and does not necessarily reflect the Government policies or approach.
[4] https://www.roadnationals.org.au/road-race.html

fires. Therefore, there is a risk that during a bush fire, at least one, two or sometimes more roads are at risk of being closed. Additionally, there is a risk that a fire can enter the town, which can result in some local roads within the town also becoming impassable. If roads are closed, and with reduced visibility during a bush fire, residents need to be given clear instructions about how to evacuate. A simplified diagram of the town is shown in the following figure.

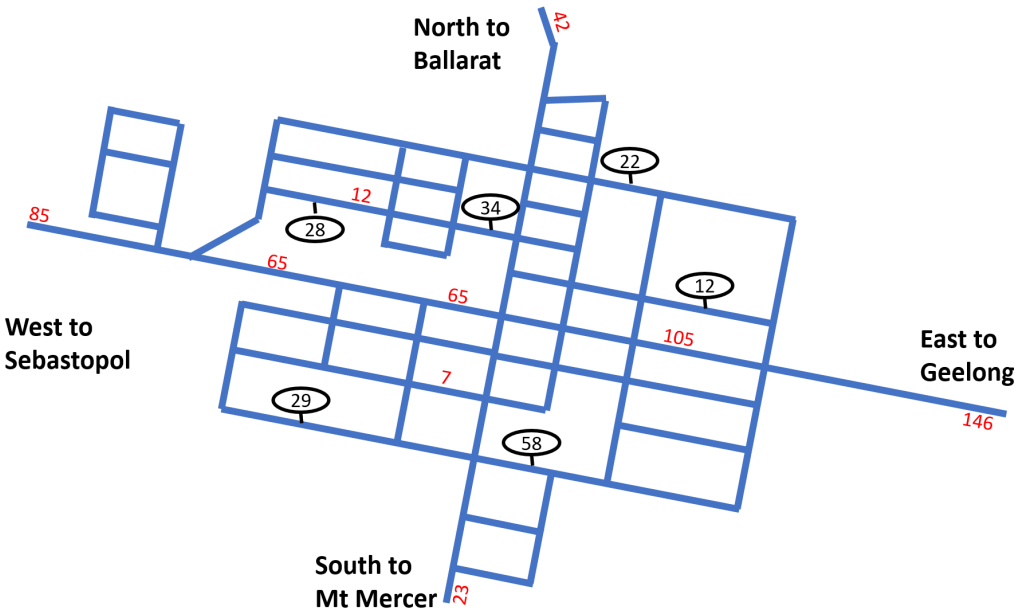

Figure 1: Simplified map of the town of Buninyong showing major roads, streets, and the four exits (North, South, East and West). Note: The black circles represent groups of residents (eg the number of cars) living on that street between the two intersections shown. Each section of road between intersections will have a black circle (only some represented here). The red numbers show example amounts of vehicles that can travel safetly (total regardless of direction) on that road over a 5 minute period (capacity).

While the proposed app will be developed for the town of Buninyong, it should also be easily adaptable to other regional and rural communities. The app will use the GPS data of user's phones overlaid over a graph-based model of the town that includes details of which roads are disconnected (cut) by fire or other causes. The model of the town will include details of how many vehicles can travel on each of the roads (examples in red) in the town within a given period of time (eg 5 minutes) – representing the through traffic (capacity) of that road (total regardless of direction). Each of the local roads also contains a number of sources (examples in black circles), representing residents' starting location (or source). The exit points (north, south, east and west) represent the successful evacuation points (or sinks).

The proposed app will be able to provide two important outputs:

- Firstly, it should be able to direct each individual to ensure the maximum number of people successfully evacuate as fast as possible. Clearly, if everyone takes the same road out, that road could become clogged. Therefore, an optimal solution will often mean sending different people in different directions out of town.
- Secondly, the app should be able to provide central fire command an estimate for how long it will take for the town to be fully evacuated.

As the fire changes the system should be able to update paths for evacuees and for the central command. That way if a road is closed the drivers can be given a new direction and central command receive a new time estimate for the evacuation.

Note: It is assumed that everyone will have the app installed, and that everyone does as they are told by the app. You can also assume that everyone is ready to leave at the moment the evacuation starts, and therefore, can assume that the road capacity is the only thing slowing down their departure.

Project Managers Suggestion

After landing in Europe your supervisor has emailed you. She mentions that she was thinking about the problem on her flight and thought the best approach would be to consider the problem as a Network-Flow problem and that she feels the Ford–Fulkerson algorithm (or a related version) would make a good starting point. She mentions that this will need to be altered from its normal form to some degree. In particular, she feels it should be able to:

- Handle multiple sources and sinks.
- Reevaluate the network if a road is closed.
- Direct vehicles at each intersection based on the number suggested by the flow algorithm. Eg if the algorithm directs 20 to the left and 5 to the right then 20 cars during each time period should be told to go left and five should be told to go to the right.
- Terminate a flow from source once all the residents have left.

Task Details

Your task is to write a 1000 - 1500 word proposal. Your proposal will include details describing: how the data in the problem will be structured; the underlying algorithms being used; how they will be modified for this specific problem; and the time/space efficiency of the approach. It is expected that you will need to research appropriate algorithms and work out an algorithmic solution to the problem. Your manager suggested the following structure to your proposal:

- Purpose of the proposal – Short clear and concise statement describing your proposal (50 words)
- Background – Detail why the project is required (do not just repeat the above background)(200 words).
- Solution – Describe specifics about your suggested solution. Include details about the data structure used, base algorithms and how they are modified for your system (650-1150 words).
- Conclusion – Summary of your approach (100 words)

Also consider the following notes:

- Algorithms, equations, diagrams and tables do not count in the word count.
- This is a High Distinction task, therefore, documentation must be professionally presented, written, and referenced. If the document is not at a standard suitable for submission to an employer as an example of what you can do, then it is not suitable for a HD.
- While there is an expected approach (the way we would approach it – as hinted above), you do not have to propose that approach. Essentially, there is no “correct” solution to this task. But there are many incorrect and inefficient solutions. It is up to you to argue the merits of your approach in your proposal and in your interview.

Please Note: this task does not require any implementation. Do not submit any code other than pseudocode algorithm descriptions of your approach.

Further Notes

As a HD task this is deliberately expected to be prepared in a tight timeline without hints beyond what is provided in the above.

Marking Process and Discussion

Like other tasks you can resubmit after your tutor (imagine they are your project manager) provides feedback (only once). Unlike other tasks this task will be graded out of 3. If the task is not at sufficient standard to be marked as complete, then it will be listed as “Fail” or “Exceeded feedback”. If it is accepted as complete, then it will receive one of 3 grades as follows:

1. Good but not to HD standard – Can be counted as D task.
2. Very Good Submission - HD
3. Excellent Submission – High HD

Your tutor will indicate after your submission the level the submission is being considered at. If this is “resubmit” or a score of 1 then they may provide advice on how to improve your submission. You can only have one resubmit to improve your work. To achieve that mark though you will need to show a sufficiently high quality interview.

A result of HD or D will be treated as other HD or D tasks. A High HD will result in a bonus of 5% to your final unit grade. The High HD grade is not expected to be given out to anyone. If it is awarded it will be due to an exceptional submission agreed to by all tutors.

Please remember a grade of HD is only for high achieving students and not all students doing this task will get a HD simply because the task was submitted. Your submission must be at a HD standard. This task may be subject to moderation by the unit teaching staff.

Criteria being considered when marking:

- Professional presentation of the report
    - Formatting of text, equations, diagrams, tables, algorithms etc.
    - Structure, spelling and grammar.
    - Correctly cited and referenced using APA style.
- Illustrated understanding of base algorithms used
- Solution to the problem is complete and convincingly justified.
- Algorithm space/time complexity is provided and explained.
- Interview showing clear understanding.
- Illustration of self-directed learning.