

Topic 1: Three Kingdoms:The Battle of Red Cliff

Introduction



The Battle of Red Cliff, also known as the Battle of Chibi, was a decisive naval battle in the winter of AD 208–209 at the end of the Han dynasty. The battle was fought between the allied forces of the southern Kingdom, which is led by **Sun Quan** and Shu Kingdom, which is led by **Liu Bei** against the numerically-superior forces of the northern warlord **Cao Cao**, the Emperor of the **Wei** kingdom.

Cao Cao was a powerful and ambitious military leader who had risen to prominence during the final years of the Han dynasty. He was a skilled strategist and had amassed a large and disciplined army under his command. In AD 208, Cao Cao led his forces southwards with the aim of consolidating his control and defeating his rivals, Sun Quan and Liu Bei.

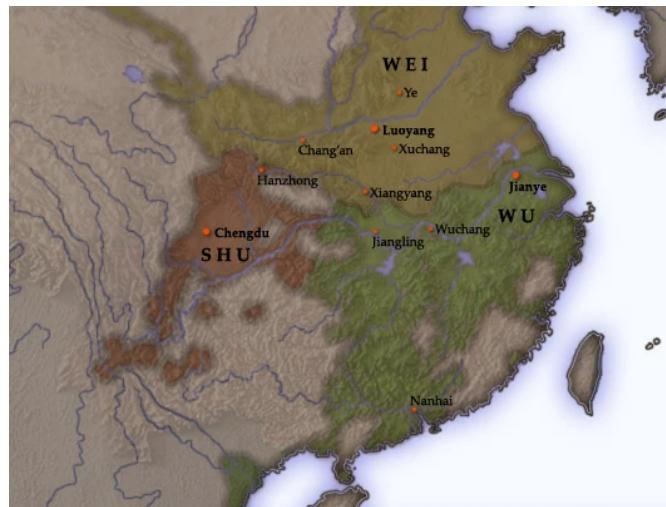
The Battle of Red Cliff lasted months, and the war took place in several places, both on the ground and on the water. The final battle takes place in a river near a cliff, thus the name 'The Battle of the Red Cliff'.

During the battle, the allied forces of Sun Quan and Liu Bei employed a range of tactics, including fire attacks, to destroy Cao Cao's ships and disrupt his supply lines. They also

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used their superior knowledge of the terrain to lure Cao Cao's forces into a trap, where they were surrounded and decimated by the allied troops. In the end, the allied forces emerged victorious, and Cao Cao was forced to retreat northwards with his army.



Forces of the Three Kingdom drawn on an ancient map

Sun Quan is the Wu Kingdom's emperor. He is also known as Eastern Wu or **Sun Wu**:

No.	Character	Ability Details												
1.		<p>Name: Sun Quan Army Type: Cavalry</p> <p>Ability Table</p> <table border="1"><caption>Ability Table</caption><thead><tr><th>Attribute</th><th>Value</th></tr></thead><tbody><tr><td>Leadership</td><td>98</td></tr><tr><td>Strength</td><td>96</td></tr><tr><td>Intelligence</td><td>72</td></tr><tr><td>Politic</td><td>77</td></tr><tr><td>Hit point</td><td>95</td></tr></tbody></table> <p>Strength: 96, Leadership: 98, Intelligence: 72, Politic: 77, Hit Point: 95</p>	Attribute	Value	Leadership	98	Strength	96	Intelligence	72	Politic	77	Hit point	95
Attribute	Value													
Leadership	98													
Strength	96													
Intelligence	72													
Politic	77													
Hit point	95													

Problem Statement

In this assignment, you're Sun Quan's loyal minister and brilliant strategist who processes the knowledge of data structures and algorithms. You are required to help Sun Quan to win the battle against Cao Cao, the ruler of Wei Kingdom in The Battle of Red Cliff.

Cao Cao

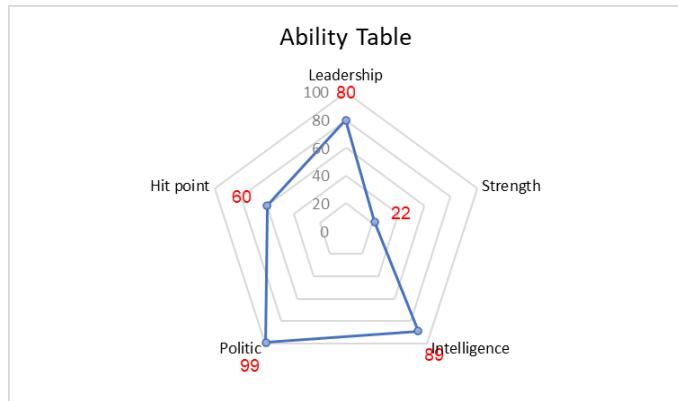


Basic Features/Requirements (12 marks)

1. Forming Wu Kingdom's Hierarchy (2 marks)

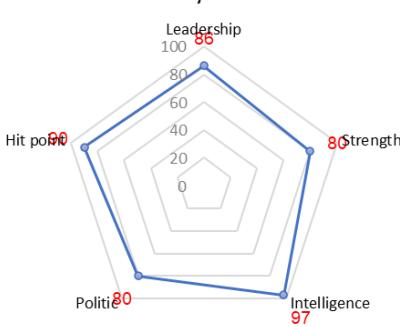
To manage human resources easily, Sun Quan decides to have a Wu kingdom hierarchy.

Sun Quan appointed Zhou Yu as the **Chief of Military** and Zhang Zhao as the **Chief of Management**. These are the details:

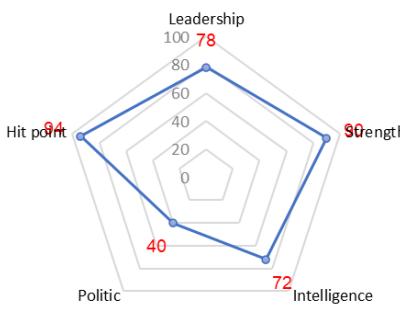
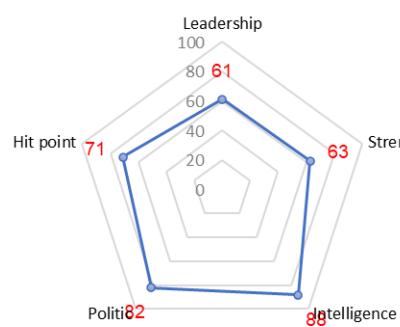
No.	Character	Ability Details
1.	 Name: Zhang Zhao Army Type: Archer	<p>Ability Table</p>  <p>Strength: 22, Leadership: 80, Intelligence: 89, Politic: 99, Hit Point: 60</p>

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2.  Name: Zhou Yu Army Type: Cavalry	<p>Ability Table</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Ability</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Leadership</td> <td>86</td> </tr> <tr> <td>Strength</td> <td>80</td> </tr> <tr> <td>Intelligence</td> <td>97</td> </tr> <tr> <td>Politic</td> <td>80</td> </tr> <tr> <td>Hit point</td> <td>90</td> </tr> </tbody> </table> <p>Strength: 80, Leadership: 86, Intelligence: 97, Politic: 80, Hit Point: 90</p>	Ability	Value	Leadership	86	Strength	80	Intelligence	97	Politic	80	Hit point	90
Ability	Value												
Leadership	86												
Strength	80												
Intelligence	97												
Politic	80												
Hit point	90												

Besides the two Chiefs, there are also **Generals**, acting as troop unit leaders. They belong either to the military department or the management department:

No.	Character	Ability Details												
1.	 Name: Xu Sheng Army Type: Archer	<p>Ability Table</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Ability</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Leadership</td> <td>78</td> </tr> <tr> <td>Strength</td> <td>90</td> </tr> <tr> <td>Intelligence</td> <td>72</td> </tr> <tr> <td>Politic</td> <td>40</td> </tr> <tr> <td>Hit point</td> <td>94</td> </tr> </tbody> </table> <p>Strength: 90, Leadership: 78, Intelligence: 72, Politic: 40, Hit Point: 94</p>	Ability	Value	Leadership	78	Strength	90	Intelligence	72	Politic	40	Hit point	94
Ability	Value													
Leadership	78													
Strength	90													
Intelligence	72													
Politic	40													
Hit point	94													
2.	 Name: Zhu Ge Jin Army Type: Archer	<p>Ability Table</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Ability</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Leadership</td> <td>61</td> </tr> <tr> <td>Strength</td> <td>63</td> </tr> <tr> <td>Intelligence</td> <td>88</td> </tr> <tr> <td>Politic</td> <td>82</td> </tr> <tr> <td>Hit point</td> <td>71</td> </tr> </tbody> </table> <p>Strength: 63, Leadership: 61, Intelligence: 88, Politic: 82, Hit Point: 71</p>	Ability	Value	Leadership	61	Strength	63	Intelligence	88	Politic	82	Hit point	71
Ability	Value													
Leadership	61													
Strength	63													
Intelligence	88													
Politic	82													
Hit point	71													

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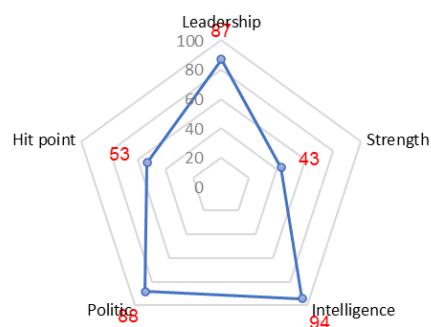
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3.



Name: Lu Su
Army Type: Infantry

Ability Table



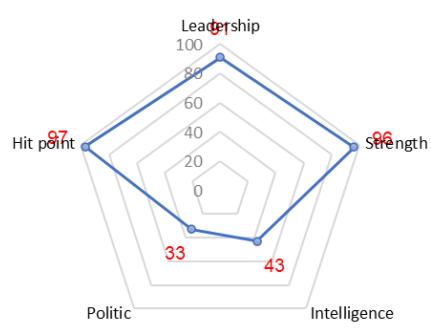
Strength: 43, Leadership: 87, Intelligence: 84, Politic: 88, Hit Point: 53

4.



Name: Tai Shi Ci
Army Type: Cavalry

Ability Table



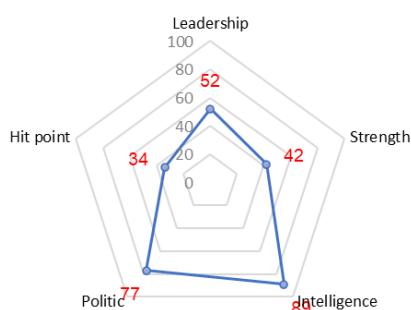
Strength: 96, Leadership: 81, Intelligence: 43, Politic: 33, Hit Point: 97

5.



Name: Xiao Qiao
Army Type: Infantry

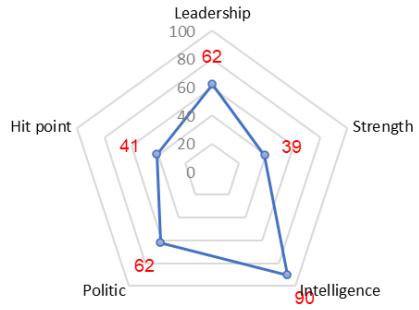
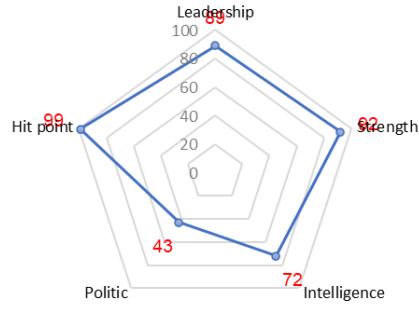
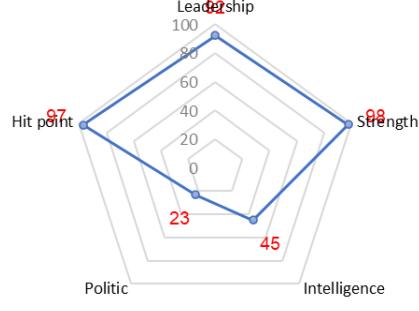
Ability Table



Strength: 42, Leadership: 52, Intelligence: 89, Politic: 77, Hit Point: 34

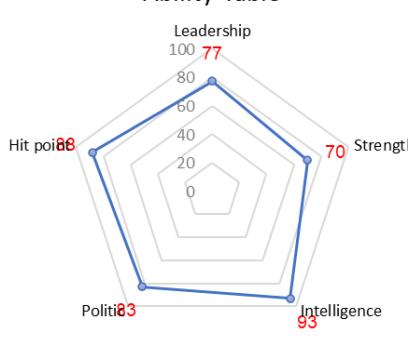
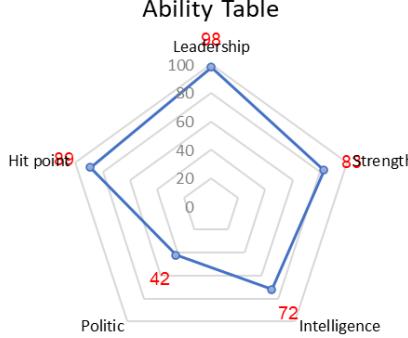
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6.	 Name: Da Qiao Army Type: Cavalry	<p style="text-align: center;">Ability Table</p>  <table border="1"><thead><tr><th>Ability</th><th>Value</th></tr></thead><tbody><tr><td>Strength</td><td>39</td></tr><tr><td>Leadership</td><td>62</td></tr><tr><td>Intelligence</td><td>90</td></tr><tr><td>Politic</td><td>62</td></tr><tr><td>Hit point</td><td>41</td></tr></tbody></table> <p>Strength: 39, Leadership: 62, Intelligence: 90, Politic: 62, Hit Point: 41</p>	Ability	Value	Strength	39	Leadership	62	Intelligence	90	Politic	62	Hit point	41
Ability	Value													
Strength	39													
Leadership	62													
Intelligence	90													
Politic	62													
Hit point	41													
7	 Name: Zhou Tai Army Type: Infantry	<p style="text-align: center;">Ability Table</p>  <table border="1"><thead><tr><th>Ability</th><th>Value</th></tr></thead><tbody><tr><td>Strength</td><td>92</td></tr><tr><td>Leadership</td><td>89</td></tr><tr><td>Intelligence</td><td>72</td></tr><tr><td>Politic</td><td>43</td></tr><tr><td>Hit point</td><td>99</td></tr></tbody></table> <p>Strength: 92, Leadership: 89, Intelligence: 72, Politic: 43, Hit Point: 99</p>	Ability	Value	Strength	92	Leadership	89	Intelligence	72	Politic	43	Hit point	99
Ability	Value													
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8	 Name: Gan Ning Army Type: Archer	<p style="text-align: center;">Ability Table</p>  <table border="1"><thead><tr><th>Ability</th><th>Value</th></tr></thead><tbody><tr><td>Strength</td><td>98</td></tr><tr><td>Leadership</td><td>92</td></tr><tr><td>Intelligence</td><td>45</td></tr><tr><td>Politic</td><td>23</td></tr><tr><td>Hit point</td><td>97</td></tr></tbody></table> <p>Strength: 98, Leadership: 92, Intelligence: 45, Politic: 23, Hit Point: 97</p>	Ability	Value	Strength	98	Leadership	92	Intelligence	45	Politic	23	Hit point	97
Ability	Value													
Strength	98													
Leadership	92													
Intelligence	45													
Politic	23													
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9  Name: Lu Meng Army Type: Cavalry	<p style="text-align: center;">Ability Table</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Ability</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Leadership</td> <td>77</td> </tr> <tr> <td>Strength</td> <td>70</td> </tr> <tr> <td>Intelligence</td> <td>93</td> </tr> <tr> <td>Politic</td> <td>83</td> </tr> <tr> <td>Hit Point</td> <td>88</td> </tr> </tbody> </table> <p style="text-align: center;">Strength: 70, Leadership: 77, Intelligence: 93, Politic: 83, Hit Point: 88</p>	Ability	Value	Leadership	77	Strength	70	Intelligence	93	Politic	83	Hit Point	88
Ability	Value												
Leadership	77												
Strength	70												
Intelligence	93												
Politic	83												
Hit Point	88												
10  Name: Huang Gai Army Type: Infantry	<p style="text-align: center;">Ability Table</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Ability</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Leadership</td> <td>98</td> </tr> <tr> <td>Strength</td> <td>83</td> </tr> <tr> <td>Intelligence</td> <td>72</td> </tr> <tr> <td>Politic</td> <td>42</td> </tr> <tr> <td>Hit Point</td> <td>89</td> </tr> </tbody> </table> <p style="text-align: center;">Strength: 83, Leadership: 98, Intelligence: 72, Politic: 42, Hit Point: 89</p>	Ability	Value	Leadership	98	Strength	83	Intelligence	72	Politic	42	Hit Point	89
Ability	Value												
Leadership	98												
Strength	83												
Intelligence	72												
Politic	42												
Hit Point	89												

Use a **tree** data structure to implement the hierarchy that includes the Emperor Sun Quan himself, the two Chiefs of military and management, and the Generals.

The **Generals** are assigned to either the management department or the military department according to their expertise. Make the assignment automatic to ease the work of Sun Quan. The term and conditions for the assignment are:

- if the General's intelligence > strength, assign to the management department
- if the General's strength > intelligence, assign to the military department

The kingdom's hierarchy shall be a three-level tree hierarchy.

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2. Soldier's Arrangement (1 mark)

Arranging his Generals is a challenging task for Sun Quan, as he strives to maintain a particular order consistently. He wants the Generals to always be sorted. Use various sorting methods based on different attributes, such as Leadership, Strength, Intelligence, Political Skill, Hit Point to sort the Generals.

Sort the General based on their ability. Then, use binary search to search a General with a specific ability.

Then using binary search, suggest 3 Generals in one team in each field (politic, leadership, strength, intelligence) with the minimum requirement S level, A level, B level, and C level:

S level: sum of ability ≥ 250

A level: sum of ability ≥ 220

B level: sum of ability ≥ 190

C level: sum of ability ≤ 190

3. Borrowing Arrows with Straw Boats (1 mark)



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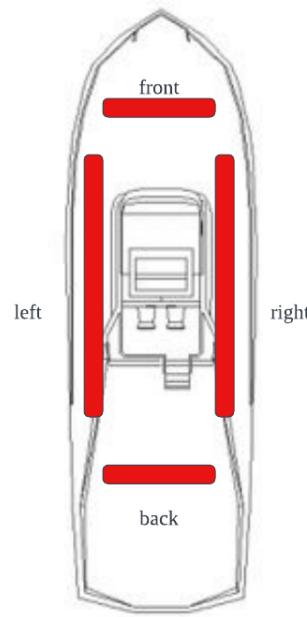
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To win the battle against Cao Cao, having enough weapon resources such as arrows is very important. However, the Wu kingdom is currently short of arrows and the production of arrows takes time. The smartest military strategist, Zhu Ge Liang has come up with a brilliant. He foresees the river field will be filled with fog one day. He will deceive the enemy by covering boats with straw men to make them appear as real soldiers thanks to the fog, and then use this ruse to trick the enemy into believing that they are attacking a larger force. As the enemy fires their arrows at the straw men, Zhu Ge Liang and his troops will retrieve the arrows and use them against the enemy, thereby gaining an advantage in battle. This clever tactic demonstrates the power of strategy and the importance of using one's wits to outsmart the opponent.



Zhu Ge Liang

Zhu Ge Liang has designed the boat that will be used to capture the arrows, as in the diagram below:



There are four directions of the boats, the straw men are placed along the edge of the boat **front, right, back, and left** (red area in the diagram above).

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There are several conditions:

1. The number of straw men placed is different across all four sides.
2. The enemy will shoot **N** waves of arrows. The number of arrows shot in each wave will decrease gradually, which means it's in decreasing order.
3. The capture efficiency decreases after the first wave of arrows since some of the straw men are depleted after capturing some arrows.
4. The number of straw men in one direction is always less than 100. The number of arrows captured in one direction is calculated as: number of arrows * (number of straw men left/100)

The example below shows how the capture efficiency drops in **one direction**:

1st wave arrow: 1000 arrows

100 straw men at 100% efficiency

100 straw men can get $1000 * (100/100) = 1000$ arrows

2nd wave arrow: 1000 arrows

Efficiency is 80% left -> $(100 * 0.8) = 80$ straw men

80 straw men can get $1000 * (80/100) = 800$ arrows

3rd arrow: 1000 arrows

Efficiency is 40% left -> $(100 * 0.4) = 40$ straw men

40 straw men can get $1000 * (40/100) = 400$ arrows

4th arrow: 1000 arrows

Efficiency is 0% left -> $(100 * 0) = 0$ straw men

0 straw men can get $1000 * (0/100) = 0$ arrows

Thus, the straw men cannot be used more than 3 times.

The boats are ought to turn such that in each wave, one face of the boat is always facing the enemy. Example: left, right, left, right, front.

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Considering the different number of straw men placed in each direction and the fact that the capture efficiency will drop, help Zhu Ge Liang to determine the best direction for the boat to face the enemy in each wave to maximize the arrows captured.

Example input:

Number of straw men

Front: 10

Left: 50

Right: 50

Back: 15

Arrow: [2000,1500,1000,800,600,500,300,300]

Example output:

Boat direction: [left, right, left, right, left, right, back, front]

Arrow received: [1000, 750, 400, 320, 120, 100, 45, 36]

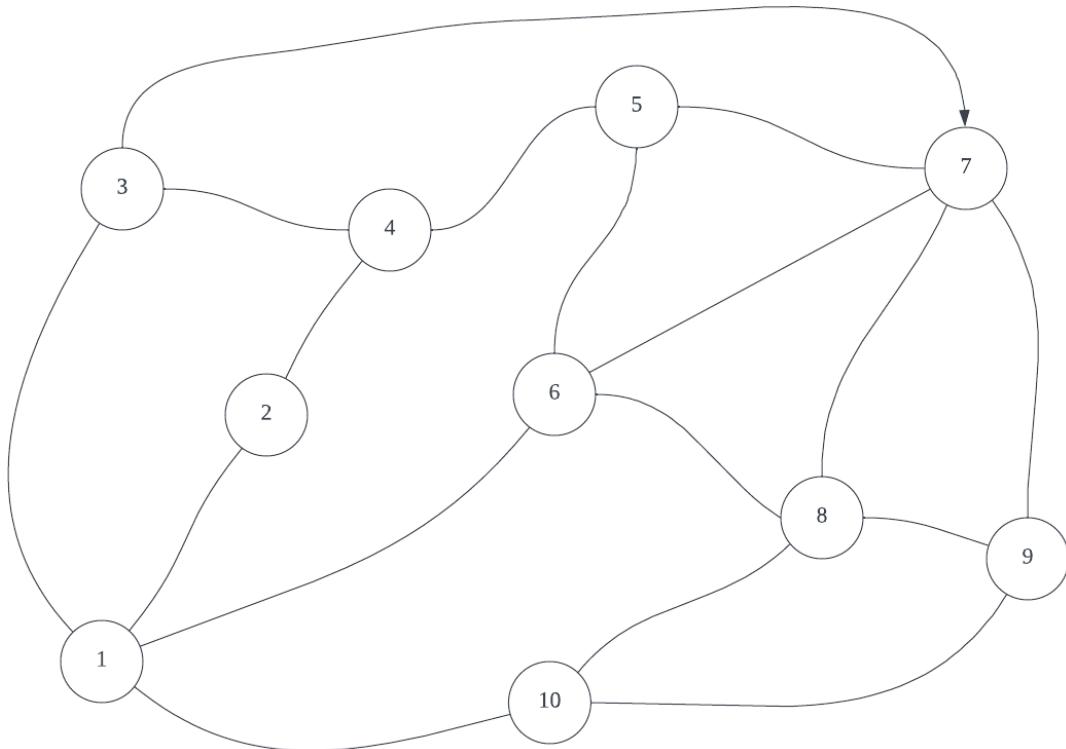
Total = 2771

4. Enemy Fortress Attack Simulation (2 marks)

Before the Battle of the Red Cliff, Cao Cao had also built a fortress on the battlefield as their headquarters.



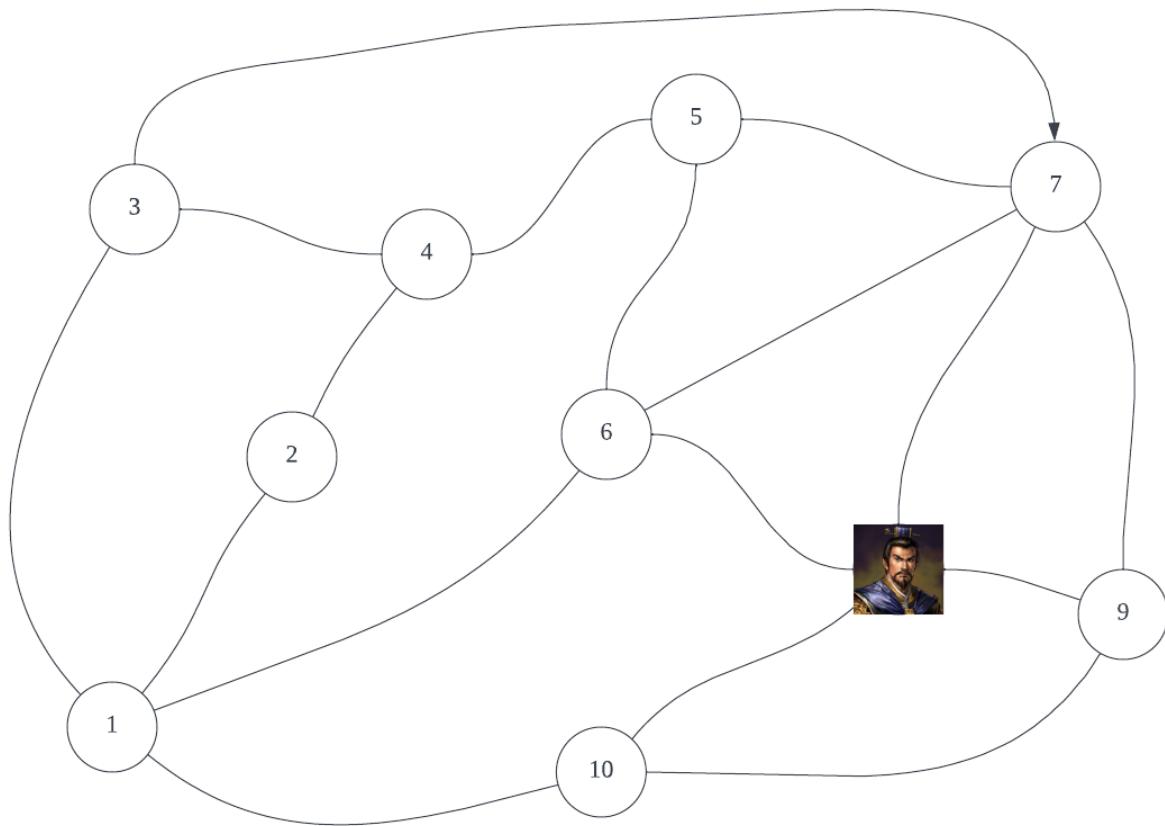
Graph: example for the battlefield



Graph for map

Node 1 is the starting point. Node 3 to Node 7 is a directed edge.

Display all the possible paths, considering that the time taken to travel to each location is the same. Use a breadth-first search algorithm to find all possible paths to reach the enemy's base camp.



Graph showing the base camp is at the node 8

Example output:

Enter the base camp for the enemy base camp: 8

Best path:

1-> 6-> 8

1-> 10 -> 8

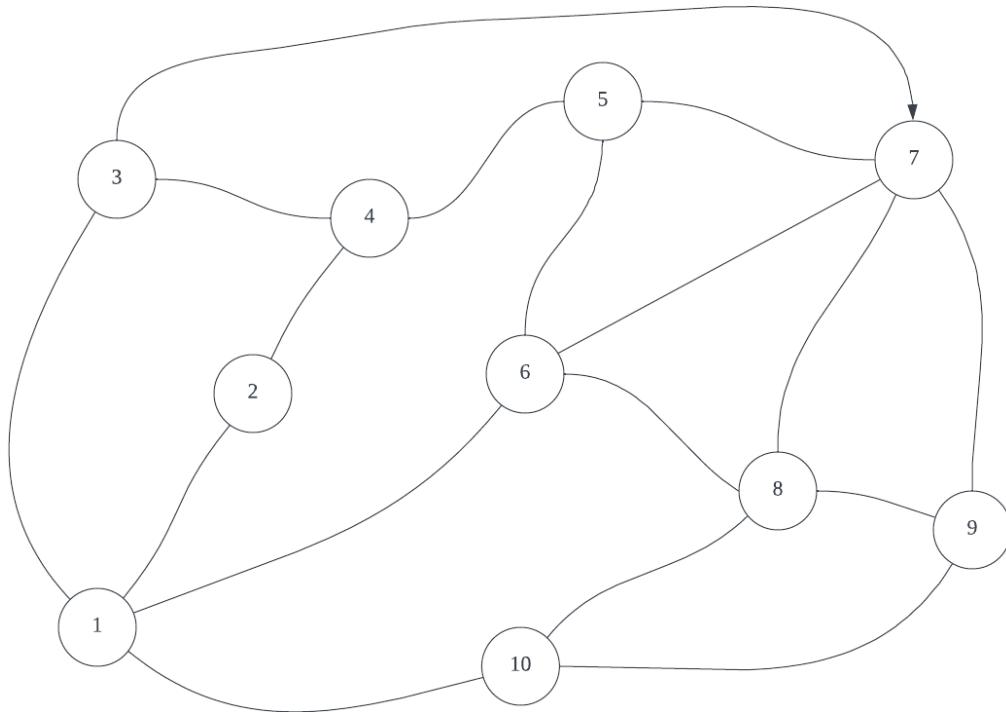
Enter the base camp for the enemy base camp: 7

Best path:

1-> 3-> 7

1-> 6-> 7

5. Food Harvesting (2 marks)



You need to depart from Sun Wu's camp (**Node 1**) and harvest all of the food on each node and back to Sun Wu's camp (**Node 1**) without passing through a node twice. Please find out the path.

Then, sometimes some of the nodes may not have food, so you may not need to go to that node.

Example: Node 9 doesn't have food this time. So your path should not have node 9 and return a new path to return node 1. If the node is 8 and you must pass through that node in order to connect all food. Then, you should include node 8 in your path.

Example input:

Enter node without food: 9

Example output:

Path:

<answer_path>

6. Encrypted Text (1 mark)



To penetrate the enemy forces, steal the enemy's information, and manipulate the enemy's decisions, Sun Quan assigned a spy, Pang Tong as Cao Cao' s loyal minister. For Sun Quan to communicate with Pang Tong, they cannot write letters in a pure language but instead, have to encrypt the text so that only both of them can understand the text. They decided to use Caeser Cipher as their encryption algorithm.

The other syntax of the encrypted text is also given below:

^	Character after this symbol is capitalized
\$	Space character
()	The text inside parentheses is inverted

Help Pang Tong decipher the letter sent by Sun Quan. Your program should be able to take in an input text, and shifting position. Encryption and decryption should be shown:

Example input:

Text: ^hkcpzl\$^jhv\$^jhv\$av\$bzl\$^aol\$^johpu\$^zayhalnl,\$(ojpod)\$pz\$av\$johpu\$opz\$(zw pozlsaahi)\$dpao\$zayvun\$pyvu\$johpu.

Shift: 7

Example output:

Advise Cao Cao to use The Chain Strategem, which is to chain his battleships with strong iron chains.

7. Red Cliff on Fire (1 mark)



Everything is well prepared before the final battle. Sun Quan's forces have enough arrows, enough food. They cleared the enemy's base camp on the battleground. Moreover, Cao Cao had used *The Chain Strategem* as advised by spy Pang Tong, which is the decision that will make him regret.

A 2D matrix that contains the position of all Cao Cao chained battleships will be provided by Pang Tong. Sun Quan will catapult fireballs to the battleships. Upon landing, the fireball will gradually spread between Cao Cao chained battleships with the help of the east wind.

```
1 1 0 0 1 0 0 1 1 1  
1 0 0 0 1 0 0 0 1 0  
1 0 1 1 1 0 1 0 1 0  
1 0 0 0 0 0 1 0 0 0  
1 0 1 1 1 1 1 1 1 1  
0 0 0 0 0 0 0 0 0 0  
1 1 1 1 0 1 1 0 1 0  
1 0 0 0 0 0 0 1 0  
1 0 0 0 1 0 1 1 1  
1 0 0 0 1 0 0 0 0 0
```

1 denotes the battleship, 0 denotes the position without a battleship. A group of chained battleships (straight and diagonal) forms a battleship **cluster** (red box in diagram below).

1	1	0	0
1	0	0	0
1	0	1	1
1	0	0	0

Find out how many **clusters** are there so that Sun Quan can determine how many fireballs to prepare.

Example Input:

```
1 1 0 0  
1 0 0 0  
1 0 1 1  
1 0 0 0
```

Example Output:

2 cluster

8. Engaging Cao Cao at Hua Rong Road (2 marks)

Finally, Cao Cao lost The Battle of Red Cliff. He retreated away from the river via Hua Rong Road and managed to escape. Hua Rong Road is a road with complex terrains. Show how Cao Cao might have retreated from Hua Rong Road so that Liu Bei and Zhao Yun can catch up with him. Besides, Guan Yu is ahead and is engaging Cao Cao at the exit of the maze.



Liu Bei



Zhao Yun



Guan Yu

This is a sample 2D maze of Hua Rong Road.

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```
1 1 1 1 1 1 1 1 1 1 1 1  
2 0 0 0 1 0 0 0 1 0 0 0 1  
1 0 1 1 1 0 1 0 1 0 1 1 1  
1 0 0 0 0 0 1 0 0 0 0 0 1  
1 0 1 1 1 1 1 1 1 0 1 1  
1 0 0 0 1 0 0 0 0 0 0 1  
1 1 1 1 1 1 1 0 1 1 1 0 1  
1 0 1 0 0 0 0 0 1 0 0 0 1  
1 0 1 0 1 0 1 1 1 1 1 1 1  
1 0 0 0 1 0 0 0 0 0 0 0 3  
1 1 1 1 1 1 1 1 1 1 1 1 1
```

2 denotes the starting point. 3 denotes the exit of the maze.

Display the path of how Cao Cao might have escaped.

Although, in real history, Cao Cao managed to escape from Sun Wu's chasing soldiers, The Battle of Red Cliff is still one of the most iconic events in the Three Kingdoms.

Extra Features (4 marks)

Graphic User Interface (GUI)

Build your Sun Wu system with a nice-looking GUI. It is possible to simulate it in a graph or in a graph with a graphic map background. Your program should simulate the process of destroying the enemy camps (movement of soldiers to the camps with respect to time).

Extra Algorithm Implementation

You can implement other searching algorithms to search for the best-known path. Here are some of the possible searching algorithms you might want to consider:

1. Best First Search
2. A* Search
3. Dijkstra algorithm

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4. Your custom searching algorithm

Dynamic Arrow Borrowing

The amount of arrow shots is not in descending order anymore, it will be in random input like the following:

Arrow: [300,1500,1000,2000,600,800,300,500,400]

The straw men are also limited to only 2 uses. Mean after 2 uses, the coefficient will be dropped to 0. It is not necessary to capture the arrow each time.

Find out how much the arrows will be and your boat direction.

Food Harvesting I

Given each node will harvest you 100 food. So, you need to assign 3 Generals in politics or intelligence to do those tasks. Note that the type of teams will buff the food production.

S team in politic = food *2

A team in politic = food *1.5

B team in politic = food *1.2

C team in politic = food * 1

S team in intelligence = food *1.8

A team in intelligence = food *1.3

B team in intelligence = food *1

C team in intelligence = food * 0.8

Maximize the food production by selecting your Generals.

Food Harvesting II

Report! Enemies ahead! All of the nodes are guarded by a number of enemies. To eliminate and capture the camps, Sun Quan wants General Xu Sheng, Lu Meng, and Xiao Qiao to occupy all the camps. Three of them have different **strength** points, denoted in Question 1.

Each node has a **soldier count**. The food can only be captured by a General having a strength point equal to or more than the **soldier count**.

A **path** is a sequence of visited and captured enemy camps by one General, starting and ending at Sun Wu's camp (Node 1). A **cost** is the total steps moved between nodes by a General. A **simulation** is a list of paths of all Generals capturing the enemy camps.

The number of enemy soldiers in each node is shown:

Node 1	0	Node 6	6
Node 2	9	Node 7	8
Node 3	8	Node 8	3
Node 4	5	Node 9	5
Node 5	3	Node 10	6

Display the simulation with the smallest cost.

Example output:

Best Simulation:

Total cost = 14

Xu Sheng:

1->10->9->8 ->10 ->1

Cost = 5

Lu Meng:

1->3->4 ->2->1

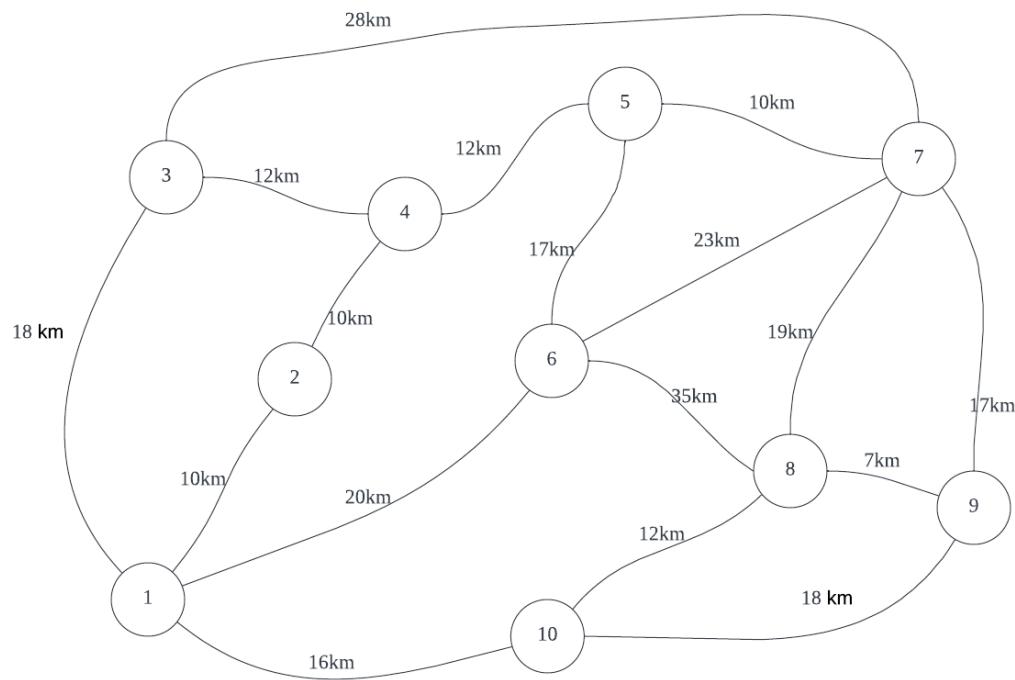
Cost = 4

Xiao Qiao:

1->6->5->7->6->1

Cost = 5

Enemy Fortress Attack Simulation I



Showing distance in the map

Even though the nodes showing the nodes are near, it is not necessary that the nodes are close. The distance and the geographical factor may cause the travel time to be different.

Given geographical factor

- Edges with flat road
 - 1 - 6
 - 1 - 3
 - 5 - 6
 - 7 - 8

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- 7 - 9
- 1 - 10
- 9 - 10
- Edges with forest
 - 1 - 2
 - 5 - 7
 - 6 - 7
 - 8 - 10
- Edges with swamp
 - 2 - 4
 - 3 - 4
 - 4 - 5
 - 8 - 9
- Edges with plank road
 - 3 - 7
 - 6 - 8

The general's speed when entering specific edges

- Cavalry - speed : 2 km/h
 - Flat road - x 3
 - Forest - x 0.8
 - Swamp - x 0.3
 - Plank road - x 0.5
- Archer - speed: 1 km/h
 - Flat road - x 2
 - Forest - x 1
 - Swamp - x 2.5
 - Plank road - x 0.5
- Infantry - speed:1 km/h
 - Flat road - x 2
 - Forest - x 2.5
 - Swamp - x 1
 - Plank road - x 0.5

Considering the geographical conditions, find again the path that would be the shortest time to reach the enemy fortress for each General.

Text Converter with More Secured Encryption

The current Caeser Cipher uses simple shifting. It is very easy for someone to guess the shifting used in the cipher, thus not used in the real world. You must now implement a different encryption algorithm that is highly secured and not prone to leakage. Besides, a new rule is introduced:

&num{}	All of the characters should be subtracted with num before decrypting it
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Also, you may also create your own cipher algorithm. You may refer to some [common encryption algorithm](#) that works. Explain how secure your encryption is.

Red Cliff on Fire with Optimized Points

Once the fireball is thrown on one coordinate in a cluster, it will spread in all 8 directions(straight and diagonal). However, throwing the fireball at random coordinates does not efficiently burn enemies' battleships.

For instance, consider the cluster below:

```
1 1 0 0 0  
1 1 1 0 0  
0 1 1 0 0  
0 1 1 0 0  
1 0 0 0 0
```

In this cluster, if the fireball is thrown on point [4,0], it would take four cycles for the whole cluster to be completely burnt (fire spreading four times). However, if the fireball is thrown on point [2,1], it would only take two cycles (fire spreading two times) for the cluster to be burnt down.

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To maximize the speed at which all battleship clusters are burned, determine the **optimal coordinates** for throwing the fireball for each cluster to ensure the enemy's battleships are burnt down in the shortest time possible. If there are 5 clusters, there shall be 5 optimal coordinates.

Special Note: Apart from the extra features listed in this document, feel free to include any other relevant extra features that spark your interest!

Tips or Recommendations

1. To optimize the implementation, it is advisable to utilize as many appropriate data structures as possible. Additionally, OOP practices are highly recommended so that your code base is well structured.
2. To collaborate with your teammates, Git version control is recommended.
3. Try to learn Graph data structure and its related algorithm, it's helpful for most of the features.
4. You might want to try out [Leetcode](#), you might get the intuition to solve some of the questions.
5. Be creative!
6. Background story:

Red Cliff movie - [Red Cliff \(2008\) - IMDb](#)

Dynasty Warrior Game - [Dynasty Warriors \(series\) | Koei Wiki | Fandom](#)

References and contact information

If you have any questions regarding the question, you can email to
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