Project 2: The Circle of Life

Lab report

1.1 The Environment

The environment is made by using a graph of nodes that are connected by edges. This graph is circular with 50 nodes and the edges are added at random for increased connectivity.
The graphs are made using the python library networkx. This library is used to create and manipulate the circular graph—functions like add_node(), add_edge() etc are used for this purpose. New edges are added to the circular graph by selecting at random a node with a degree less than 3. Edges are added to the 5 steps forward and backward nodes of this random node. This process is repeated till no more nodes can be added.

Q. With this setup, you can add at most 25 additional edges (why?). Are you always able to add this many? If not, what's the smallest number of edges you're always able to add?
If there are 50 nodes and all are connected and we increase the degree to 3 for all 50 nodes now, the number of nodes that can be added is 25 as you can just add one node to the existing nodes. This totals an addition of at most 25 nodes to all 50 nodes.

1.2 The Agents and Environment

We have defined an edge known as the overlap edge. Here, the previous and next nodes of the node in between are directly connected by another edge.
If such an "overlap edge" exists, we proceed to delete this node. This is done with the purpose of giving the agent a better chance to survive. Because if the agent were to move into the node of the overlap edge, with the predator just behind it, the predator in the next step would move towards the agent with a check-mate situation. This is because now the agent would have no escape as the predator could enter both the nodes left for the agent for the agent to choose and then would kill it.

1.2.1 Agent 1

This is a complete information setting, so the agent knows the location of the prey and the predator. This agent surveys its neighbours and selects the available neighbour in a given order.

- Neighbours that are closer to the Prey and farther from the Predator.
- Neighbours that are closer to the Prey and not closer to the Predator.
- Neighbours that are not farther from the Prey and farther from the Predator.

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- Neighbours that are not farther from the Prey and not closer to the Predator.
- Neighbours that are farther from the Predator.
- Neighbours that are not closer to the Predator.
- Sit still and pray.

```
Total Success Rates = 2649

Average Results
Average Success Rates = 88
Average Hanged Rates = 0
Average Step Size = 10
```

1.2.2 Agent 2

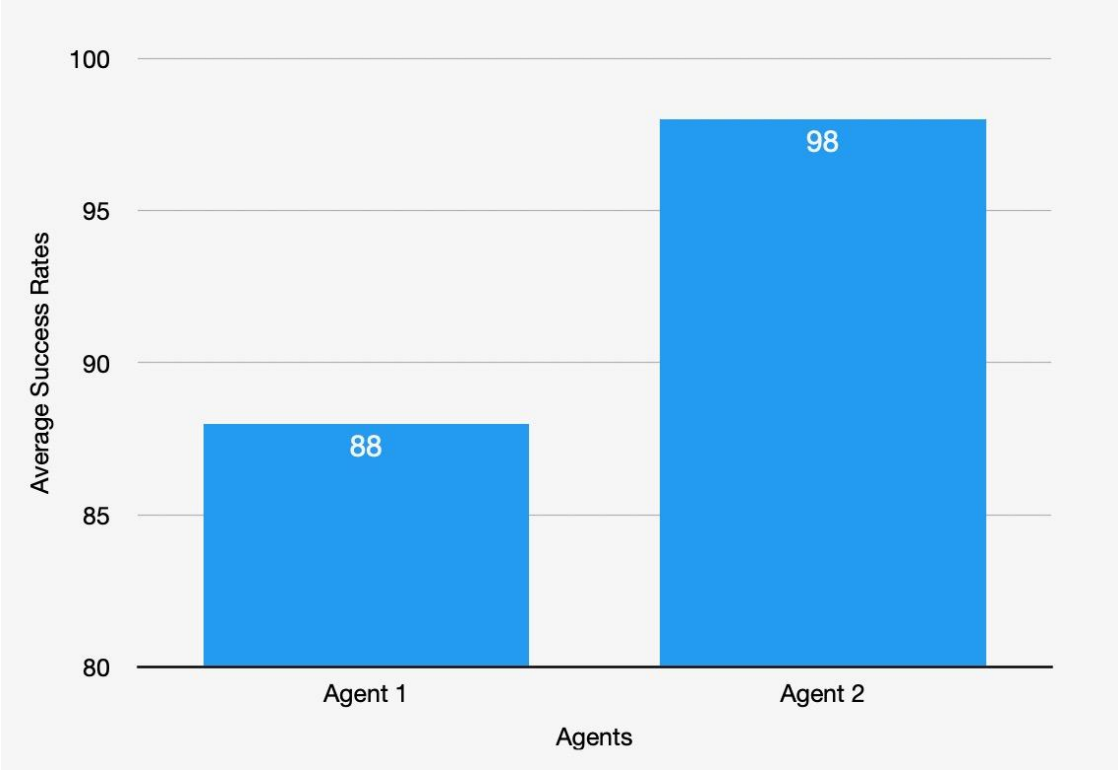
This agent surveys its neighbours and selects the available neighbour in a given order exactly like Agent 1, except for the last "sit still and pray" step. Instead of this, the agent decides the next step according to the following conditions in the given priority, if the distance between the agent and predator is 2, the agent gives preference to the neighbours in the following manner:

- More preference is given to the neighbour having less distance to the prey and more distance from the predator with no "overlap edge".
- The next preference is given to the neighbour having less distance to the prey and more distance from the predator irrespective of whether it has an "overlap edge" or not.
- Next preference is given to the neighbour with equal prey distance, less distance from prey and no "overlap edge".
- Then the preference is for the neighbour with equal prey distance, less distance from prey irrespective of whether it has an "overlap edge" or not.
- The next best choice is the neighbour with more distance to the predator with no "overlap edge".
- The final priority is given to the neighbour that has irrespective of whether it has an "overlap edge" or not.
- If none of such neighbours is found, then the agent selects a neighbour at random.

```
Total Success Rates = 2969

Average Results
Average Success Rates = 98
Average Hanged Rates = 0
Average Step Size = 11
```

Performance in complete information setting



Agent 3 and Agent 4

This is a partial information setting, so the agent always knows where the Predator is but does not necessarily know where the Prey is.

Q. How do the probability updates for the Predator differ from the probability updates for the Prey?

The probability update differs in the transitions of the prey and predator. While the prey moves randomly, selecting any node or staying in place, the predator has a 60% probability of going to the node that has the shortest distance to the agent and a 40% probability of going to any neighbour.

1.2.3 Agent 3

The agent surveys the nodes. Here, the prey will either be found or not. According to that it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below.

Agent 3 has its belief update system as mentioned:

Belief Update

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Prey Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Prey Not Found:** Every node will be updated according to the given formula.

$P(X)$ = **(**P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

4. **Prey Transition:**

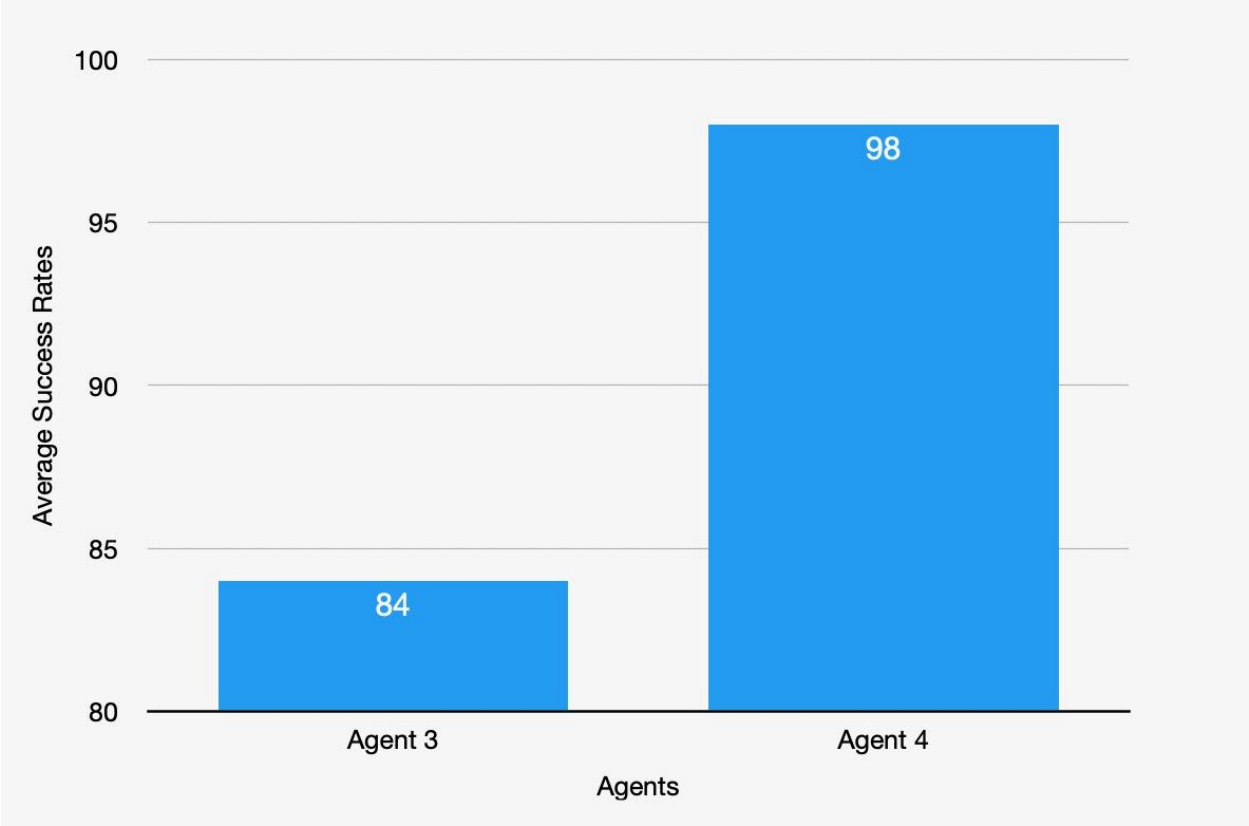
$P(X\ new \mid not\ in\ i)$ = $(P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

It updates its beliefs according to this belief system and then will act according to Agent 1.

Performance in partial prey information setting

```
Total Success Rates = 2538

Average Results
Average Success Rates = 84
Average Hanged Rates = 0.0
Average Step Size = 20.566666666666666
Average Prey Found = 0.9666666666666667
```



1.2.4 Agent 4

The agent surveys the nodes. Here, the prey will either be found or not. According to that it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below. The agent acts in accordance with agent 2.

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Prey Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Prey Not Found:** Every node will be updated according to the given formula.

$P(X)$ = **(**P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

4. **Prey Transition:**

$P(X\ new \mid not\ in\ i)$ = $(P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

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```
Total Success Rates = 2967

Average Results
Average Success Rates = 98
Average Hanged Rates = 0
Average Step Size = 24.033333333333335
Average Prey Found = 0.9666666666666667
```

Agent 5 and Agent 6

This is a partial information setting, so the agent always knows where the Predator is but does not necessarily know where the Prey is.

1.2.5 Agent 5

The agent surveys the nodes. Here, the prey will either be found or not. According to that it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below.

Agent 5 has its belief update system as mentioned:

Belief Update

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Predator Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Predator Not Found:** Every node will be updated according to the given formula.

$P(X)$ = **(**P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

4. **Predator Transition:**

$P(X\ new \mid not\ in\ i)$ = $(P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

```
Total Success Rates = 2444

Average Results
Average Success Rates = 81
Average Hanged Rates = 0.0
Average Step Size = 15
Average Predator Found = 8.933333333333334
```

1.2.6 Agent 6

The agent surveys the nodes. Here, the prey will either be found or not. According to that it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below. The agent acts in accordance with agent 2.

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Predator Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Predator Not Found:** Every node will be updated according to the given formula.

$P(X)$ = **(**P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

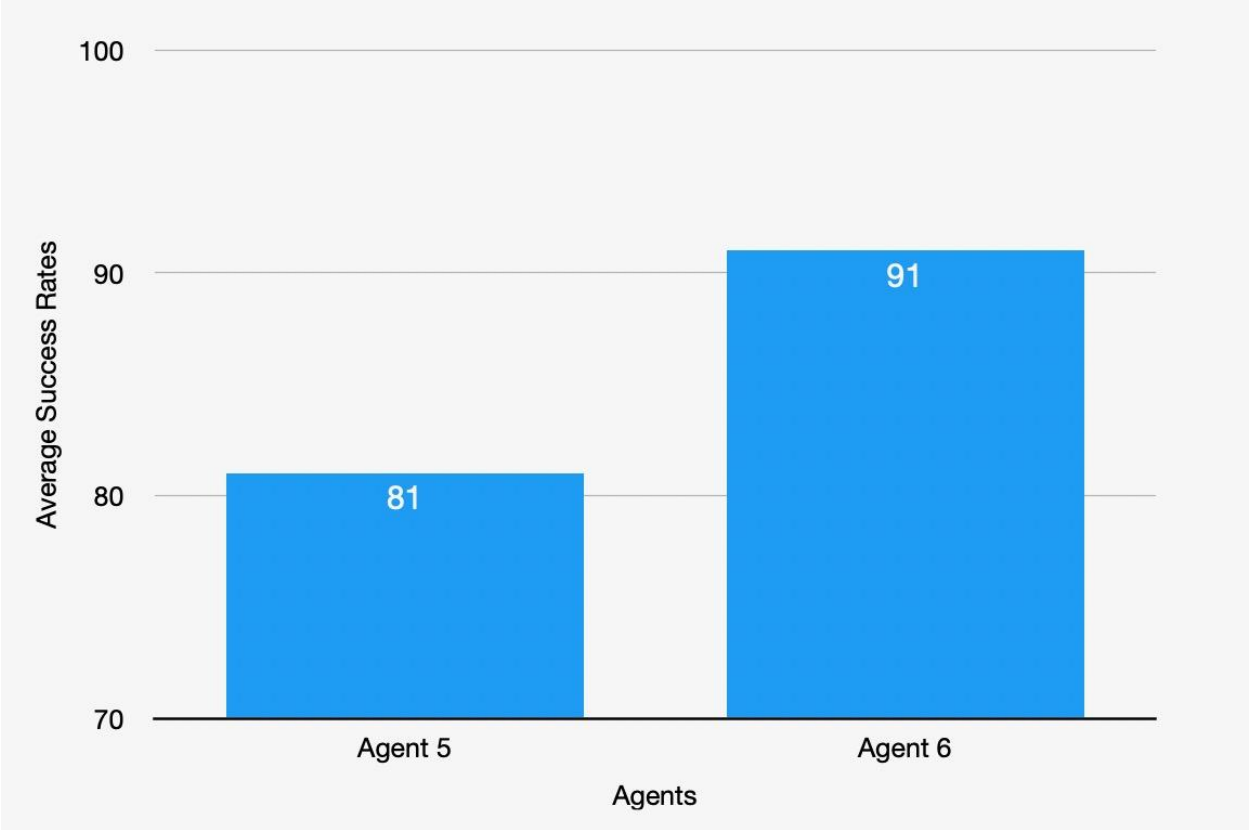
4. **Predator Transition:**

$P(X\ new \mid not\ in\ i)$ = $(P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

```
Total Success Rates = 2751

Average Results
Average Success Rates = 91
Average Hanged Rates = 0.0
Average Step Size = 15
Average Predator Found = 9.2
```

Performance in partial predator information setting



Agent 7 and Agent 8

This is a combined partial information setting, so does not necessarily know where the Prey or the Predator is.

1.2.7 Agent 7

The agent surveys the nodes. Here, the prey will either be found or not. According to that it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below.

Agent 7 has its belief update system as mentioned:

Belief Update

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Predator or Prey Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Predator or Prey Not Found:** Every node will be updated according to the given formula.

$P(X)$ = **(**P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

4. **Predator or Prey Transition:**

   $P(X\ new \mid not\ in\ i)$ = ($P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

```
Total Success Rates = 2228

Average Results
Average Success Rates = 74
Average Hanged Rates = 0.0
Average Step Size = 29
Average Prey Found = 0.0
Average Predator Found = 15
```

1.2.8 Agent 8

The agent surveys the nodes. Here, the prey will either be found or not. According to that, it will update its belief system. Then the prey will transition according to the prey transition formula that is defined below. The agent acts in accordance with agent 2.

Belief Update

1. **Initialization:** Every node will be 1/49 except for the node where there is the agent.
2. **Predator or Prey Found:** Every node will be 0 except for the node where there is prey which will be 1.
3. **Predator or Prey Not Found:** Every node will be updated according to the given formula.

$P(X)$ = (P (prey in node X)* P(prey not in survey node | prey in node X))/P(prey not in survey node)

Where,

P(prey not in survey node) = P(prey in node X) * P((Not in node X) | P(prey in node X))

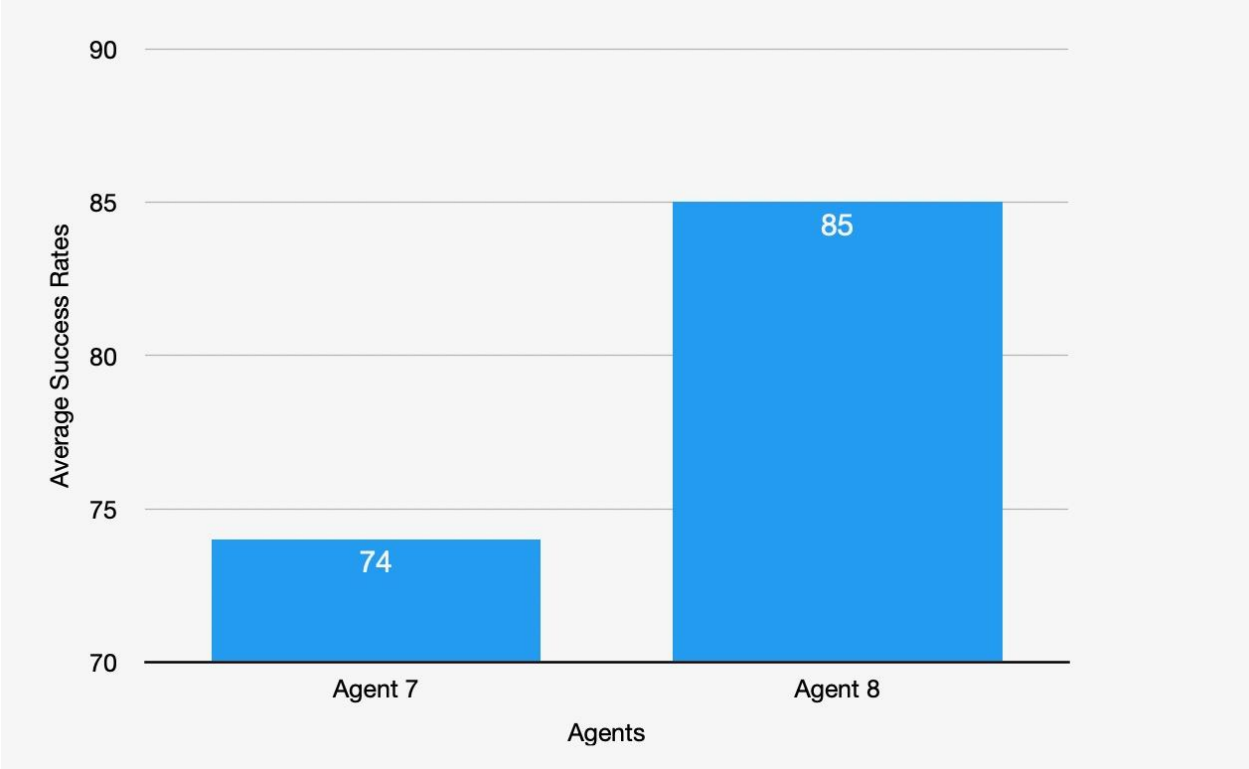
4. **Predator or Prey Transition:**

   $P(X\ new \mid not\ in\ i)$ = ($P(not\ in\ i \mid X\ prev)$ * P (X prev)) / P (not in i)

```
Total Success Rates = 2574

Average Results
Average Success Rates = 85
Average Hanged Rates = 0.0
Average Step Size = 31
Average Prey Found = 0.0
Average Predator Found = 16
```

Performance in combined partial predator information setting



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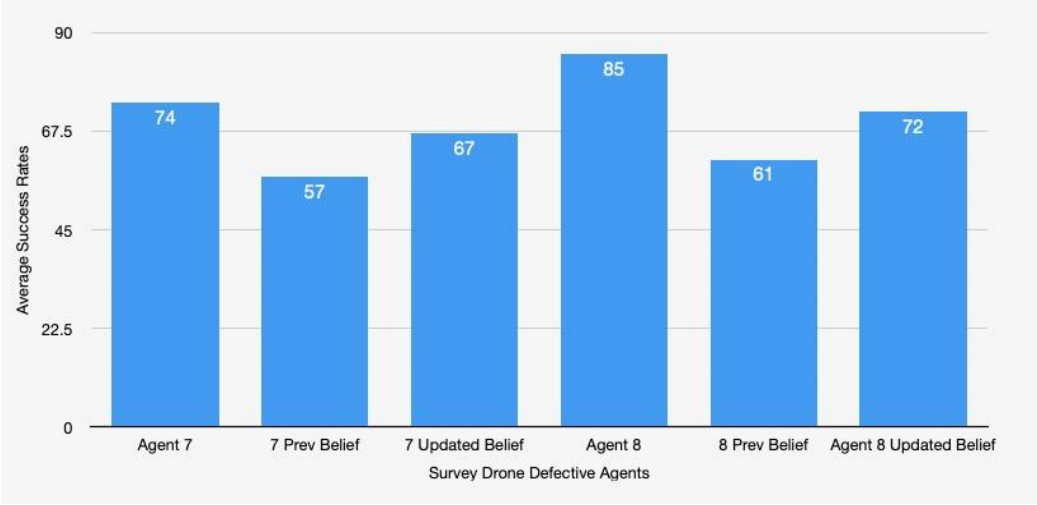
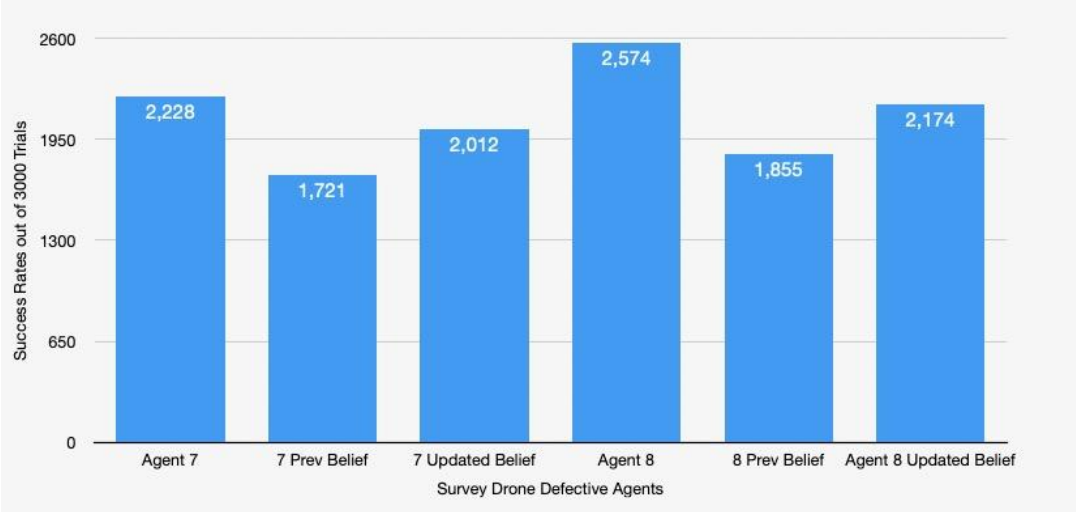
The performance in combined partial information setting, if the survey drone is defective





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Agent 9 : We can build an agent that when the survey comes out to be negative when it has a probability of over 0.75 we don't update the probability, we survey it once more so that we are sure that the node doesn't have prey/predator.

Q. How should you update your belief update rules to account for this?

The surveyed node doesn't become 0 because of the updated belief system because there is a 0.1 probability of false negative.

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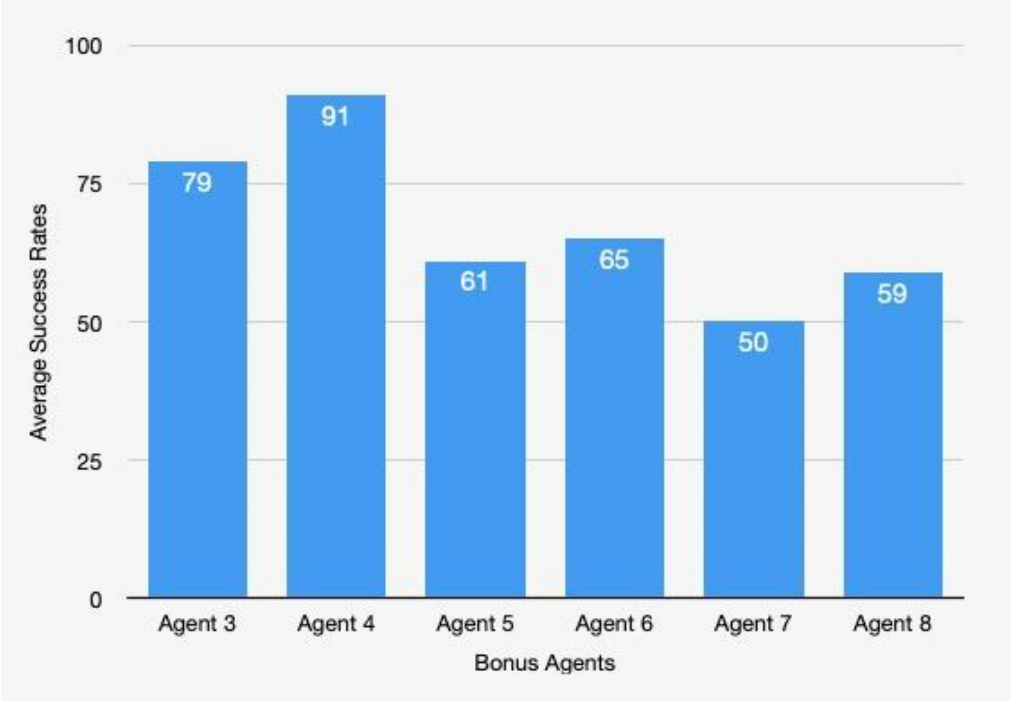
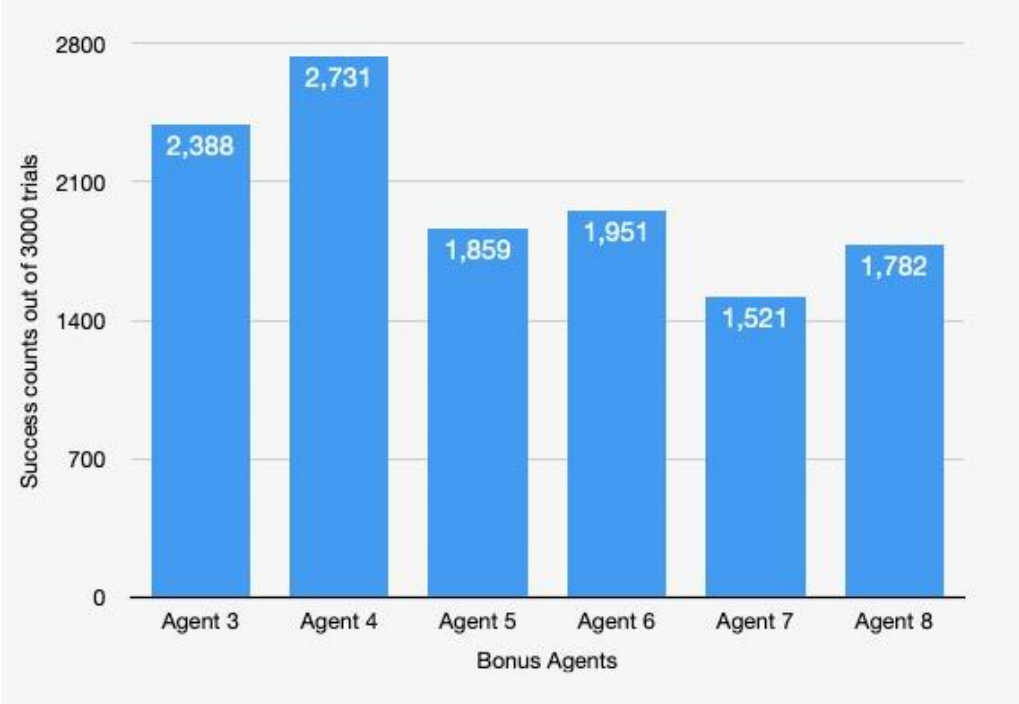
1.2.9 BONUS

The agent surveys the nodes once and moves once. If the predator is close, then the agent does not survey.The belief systems of all the agents are the same as the corresponding previous agents.

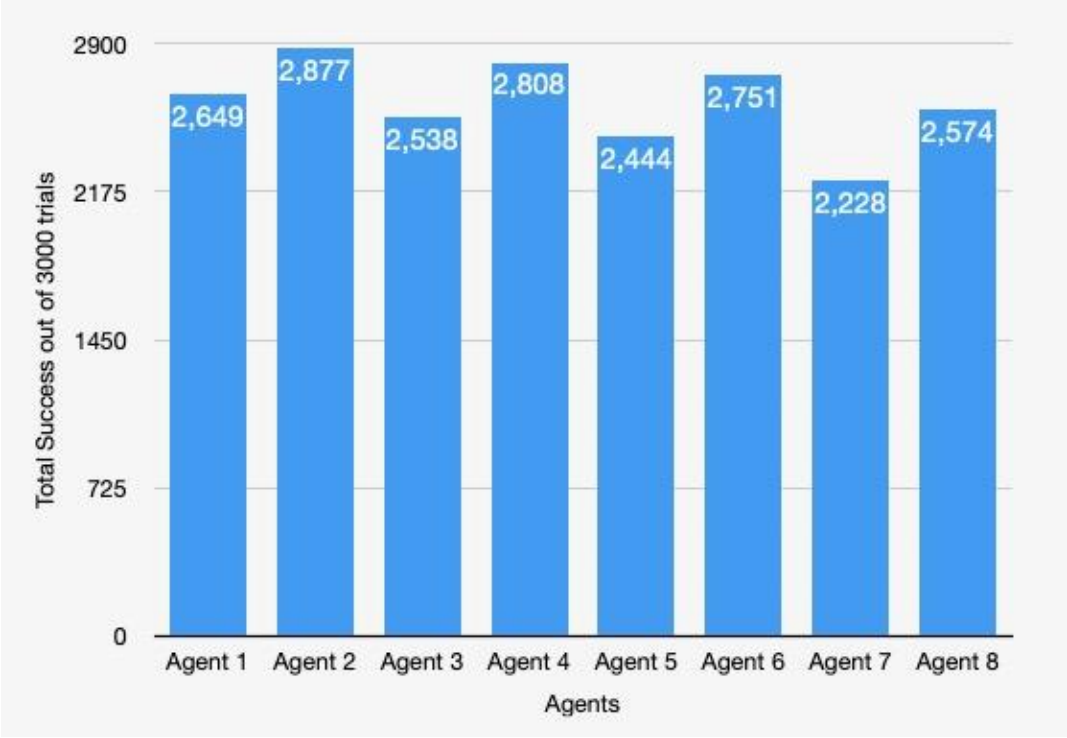
Performance





1.3 Analysis: Performance Comparison

The following is the comparative graph of all the agents' success for 3000 trials.



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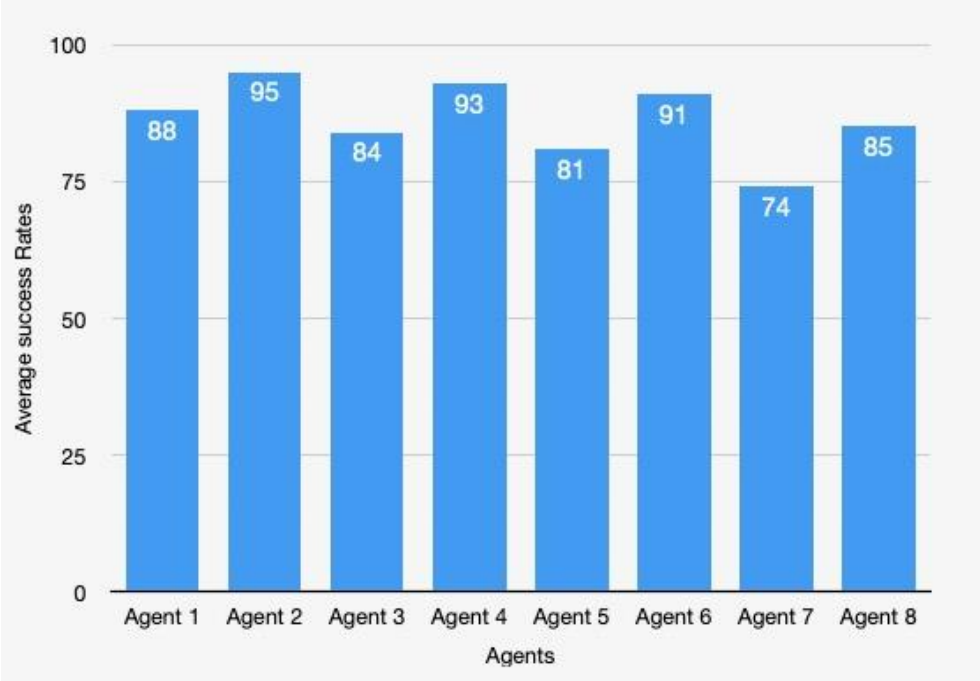
The following is the average rate of success of all the agents.



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