Dolphine Network

GROUP 4
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1 What are Dolphins?

Figure 1: Dolphins.

Dolphins may swim through the water as gracefully as any fish, but they are not fish. Dolphins are mammals. This puts them in the ranks of other famous marine mammals such as whales, seals, and manatees.

1.1 Fun Facts About Dolphins

- Dolphins are very social creatures and live together in pods. Pod life provides individuals with the companionship which is so important to them such as catch food together, raising their young and defending each other from predators.
- The bottle-nose dolphin can live up to 25 years, with a maximum age of around 40 years old.
- Bottlenose dolphins can eat between 15-30 pounds of fish every day.
- Dolphins sleep with half of their brain at a time. so half of the brain has to remain awake for them to breathe at all times.

- Human's hearing range is about 20 hz to 20 khz. Dolphins can hear sounds up to 150 khz! They can even produce sounds that we cannot hear with our ears.
- Dolphins give birth to one baby at a time every 1 to 6 years.

1.2 Behavioural Patterns of Dolphins

Male dolphins can be territorial but in a strange way. In most mammals, the alpha-males try to keep many females to themselves and will fight off any other alpha-male.

However studies in the 1990s revealed that two to three male dolphins can cooperate very closely with each other to isolate female dolphins from the main group for mating.

2 About our Network

The Dolphine Network is an undirected social network of frequent associations between 62 dolphins in a community living off Doubtful Sound, New Zealand.

Ecologist David Lusseau of the University of Aberdeen, UK, studied the social lives of a community of 62 bottlenose dolphins from 1994 to 2001. Each dolphin was marked on their dorsal fins and he kept track of individual animals via photographs.

2.1 Visualization of the Dolphine Network

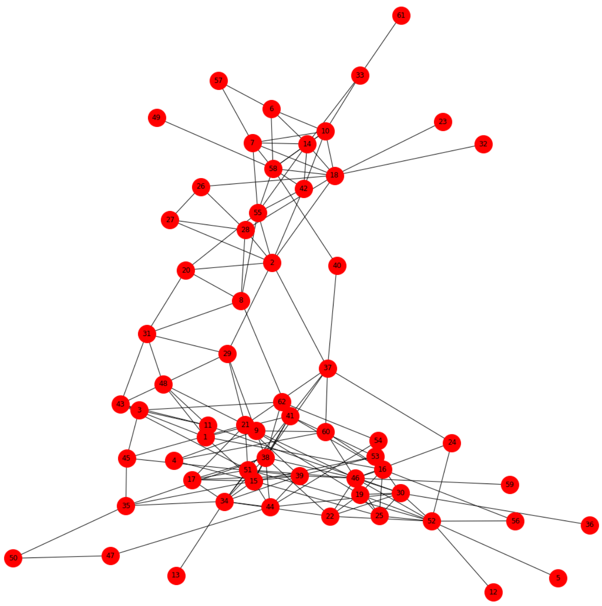

Figure 2: Visualization of the Dolphine Network.

At a glance, we see that:

- We can not tell the shape or topology of our network.
- There seems to be around two main large clusters.
- Our network is complete since every node is connected to at least one other node.

2.2 The Structure of Our Network (Is It a Complex Network)?

It is well known that there is not yet a general, all-covering definition of a complex network. However, there are attributes of real-world complex networks that we can use to draw conclusions.

Attributes of Real- World Complex Networks

1. Non-trivial Topology: This means that it is not always easy to tell the shape or topology of the network at a glance
2. Scale Free: We expect the degree distribution follows a power law (Pareto's curve).
3. Small World : In real complex networks, there is usually:
   - Small graph diameter, short average eccentricity.
     Eccentricity is the maximum distance from one node to all the others nodes.
   - Small mean-shortest path length.
4. Highly clustered: They contain a very large proportion of triangles (unlike random graphs).

2.3 Does our Network Have Similar Attributes as Complex Networks?

1. Non-trivial Topology: Indeed the topology (shape) of our network is not obvious at a glance.

2. Scale Free: Indeed the degree distribution of our network follows a power law (Pareto's Curve) as it slopes downwards implying that there are few nodes with high degree.

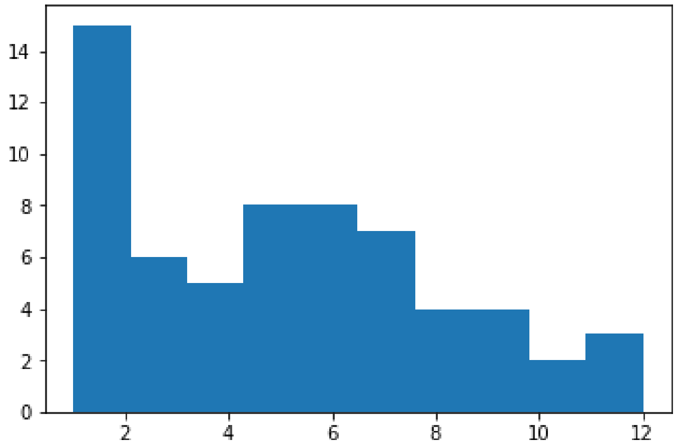

Figure 3: Pareto's Curve (Frequency against Degree)

3. **Small World** :

   - Despite having 62 nodes and 159 links, the diameter is just 8.

```
In [98]: nx.diameter(G1)
Out[98]: 8
```

Figure 4: Python output for the network's diameter.

   - Also the average eccentricity gives 6.5

```
In [18]: ecc = nx.eccentricity(G1)
         sum_ecc = 0
         for k in ecc:
             sum_ecc += ecc[k]

         average_ecc= sum_ecc / len(ecc)
         average_ecc
Out[18]: 6.5
```

Figure 5: Python output for the network's average eccentricity.

   - Also the average shortest path length is just about 3.36.

```
:  val1=nx.average_shortest_path_length(G1)
   print('The average shortest path lenght is: ', val1)

The average shortest path lenght is:  3.3569539925965097
```

Figure 6: Python output for the network's shortest path length.

3 Analysis

3.1 Some Quick Statistics

- **Description:** It is a network that shows the social interaction between 62 dolphins.
- **Nodes and links:** Our network graph contains 62 nodes and 159 links.
- **Sparcity:** A Network is said to be sparse if $L << L_{max}$

$$
\begin{aligned}
L_{max} &= \frac{N(N-1)}{2} \\
&= \frac{62(62-1)}{2} \\
&= 1891
\end{aligned}
$$

  Since 159 << 1891 we say that our network is sparse

- **Average Degree:** This is the average number of links a node has.

```
NumNodes=G1.number_of_nodes()
s=0
for i in G1.nodes():
    s+= G1.degree(i)
print('The average degree is :',s/NumNodes)
```

```
The average degree is : 5.129032258064516
```

Figure 7: Python output for the network's average number of links a node has.

- **Average Shortest Path:** This is the average smallest distance from one node to another any other node.

```
val1=nx.average_shortest_path_length(G1)
print('The average shortest path lenght is: ', val1)
```

```
The average shortest path lenght is:  3.3569539925965097
```

Figure 8: Python output for the network's average smallest distance between node pairs.

- **Degree Distribution:** The degree distribution of the dolphine network follows a power law.

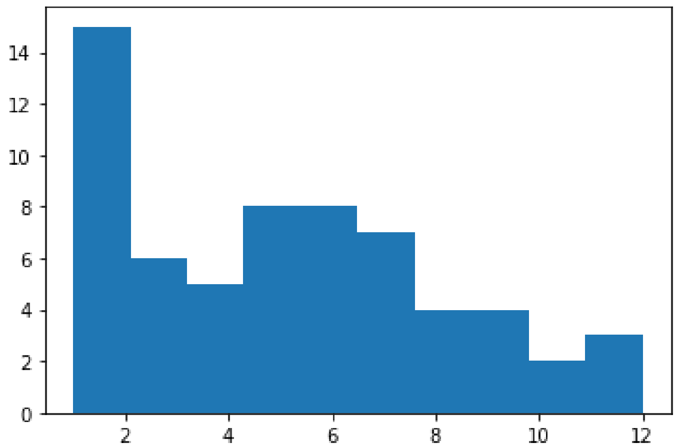

Figure 9: Degree Distribution

- **Density:** The closer this value is to 1, the network is said to be dense, else it is sparse.

```
In [17]: val2=nx.density(G1)
         print('The density of the network is:', val2)

         The density of the network is: 0.08408249603384453
```

Figure 10: Python output for the network's density.

In our case to value is close to 0, hence our network is sparse.

- **Wiener index:** The Wiener index of a graph is the sum of the shortest-path distances between each pair of reachable nodes.

```
In [111]: nx.wiener_index(G1)
Out[111]: 6348.0
```

Figure 11: Python output for the network's Wiener's index.

- **Average Clustering:** Generally speaking, 0.25 is closer to 0 than 1, so we say that neighbourhood of our nodes are not well inter-connected to each other.

```
In [145]: nx.average_clustering(G1)
Out[145]: 0.2589582460550202
```

Figure 12: Python output for the network's average clustring.

3.2 Clustering Coefficient vs Degree

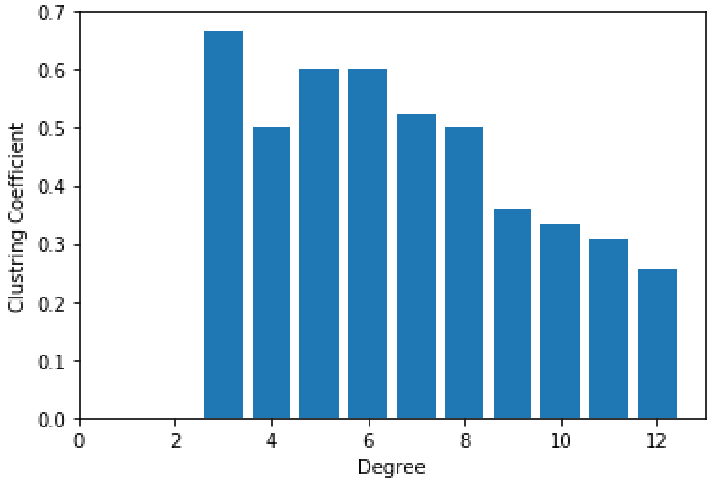

Figure 13: Clustering Coefficient vs Degree

Interpretation: As expected in real world complex networks, the clustering co-efficient is inversely proportional to the degree. This implies that the dolphins form groups of small, tightly clustered communities held together by leaders that have high degree.

3.3 Degree Centrality (force/power through links)

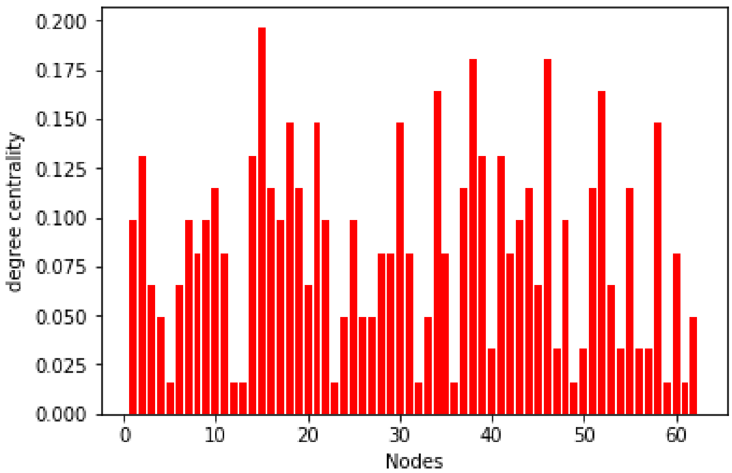

Figure 14: Bar plot of Nodes and Degree Centrality

Interpretation: From our graph, we see that node 15 (Grin) has the highest degree centrality (0.19) which implies that the Grin has the highest number of interactions with other dolphins. Grin is a social dolphin who interacts directly to the most number of dolphins

3.4 Betweenness Centrality

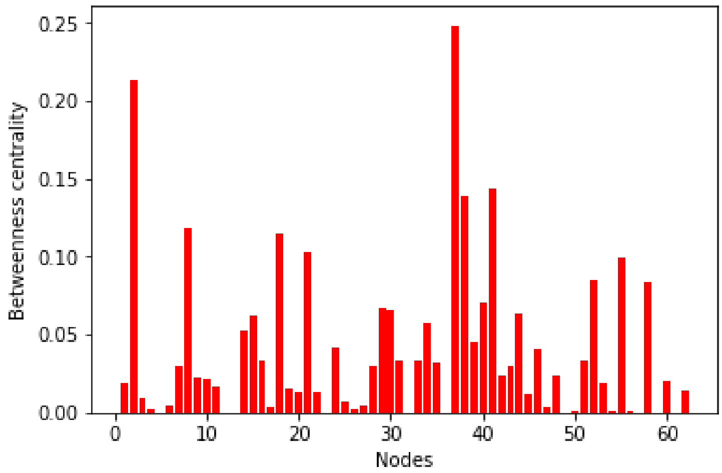

Figure 15: Barplot of Nodes and Betweenness Centrality

Interpretation: From our graph, we see that node 37 (SN100) has the highest betweenness centrality (0.24) which implies that this node lies on many short paths hence this dolphine plays an important role on passing/spreading information through the network within a short period of time.

3.5 Closeness Centrality (power through proximity to others)

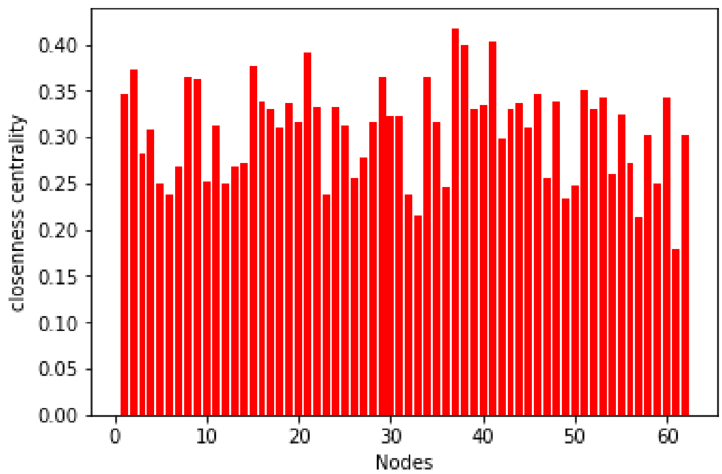

Figure 16: Barplot of Nodes and Closeness Centrality

Interpretation: Node 37 (SN100) has the highest closeness centrality (0.42) which implies that SN 100 is relatively closer to all the other dolphins than any other dolphin. SN100 may not be the most social but he that guy who is close to at least one friend of almost every dolphin. He is easily reachable and can reach others easily. SN100 is a very important dolphin in our network.

3.6 Eigenvector Centrality (Importance due to connection to Important Nodes)

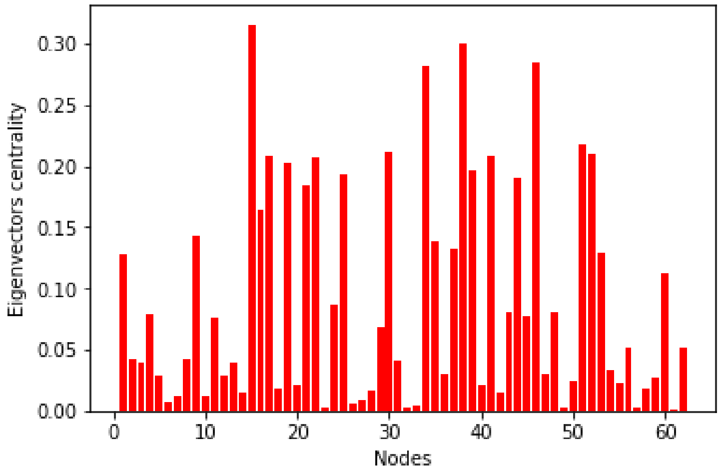

Figure 17: Barplot of Nodes and Eigenvalue Centrality

Interpretation: From our graph, we see that node 15 (Grin) has the highest eigenvector centrality (0.32) which implies that the Grin is connected to the most important nodes. Therefore, grin knows a lot of Dolphins who can help him when he needs a favour.

3.7 Subgraph Centrality (Number of subgraphs a node "participates" in)

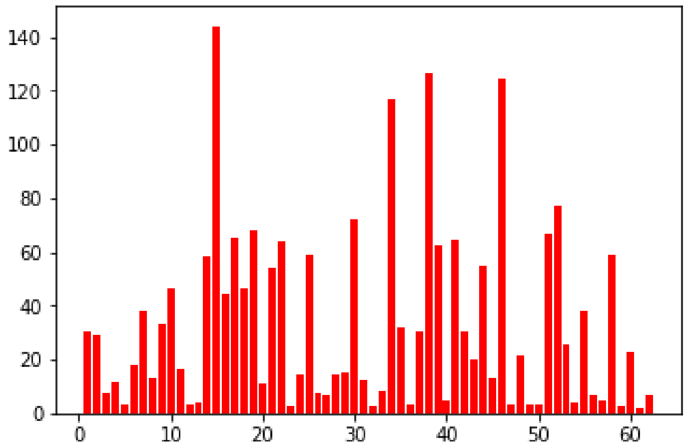

Figure 18: Barplot of Nodes and Subgraph Centrality

Interpretation: From our graph, we see that node 15 (Grin) has the highest subgraph centrality (143) which implies that node 15 is involved in the highest number of subgraphs. Hence given any random interaction between two or more Dolphins,the chances that Grin is involved is higher than for any other Dolphin.

3.8 Hierarchy Dendrogram

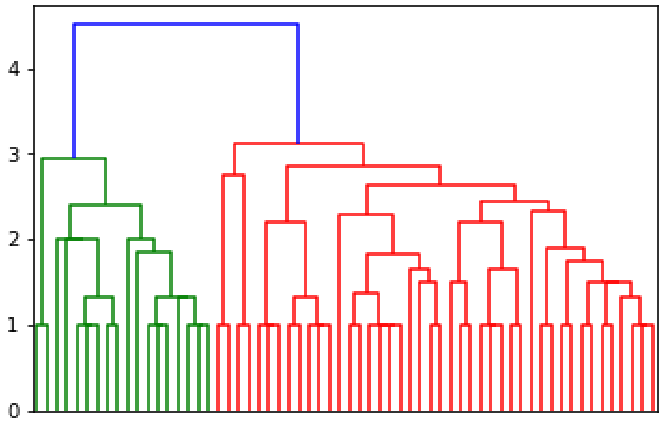

Figure 19: Hierarchy Dendrogram

Interpretation: There is a possibility of having at least two communities. Having more than two communities will not come as a surprise since the red community can easily be divided into sub-communities.

3.9 Community Detection

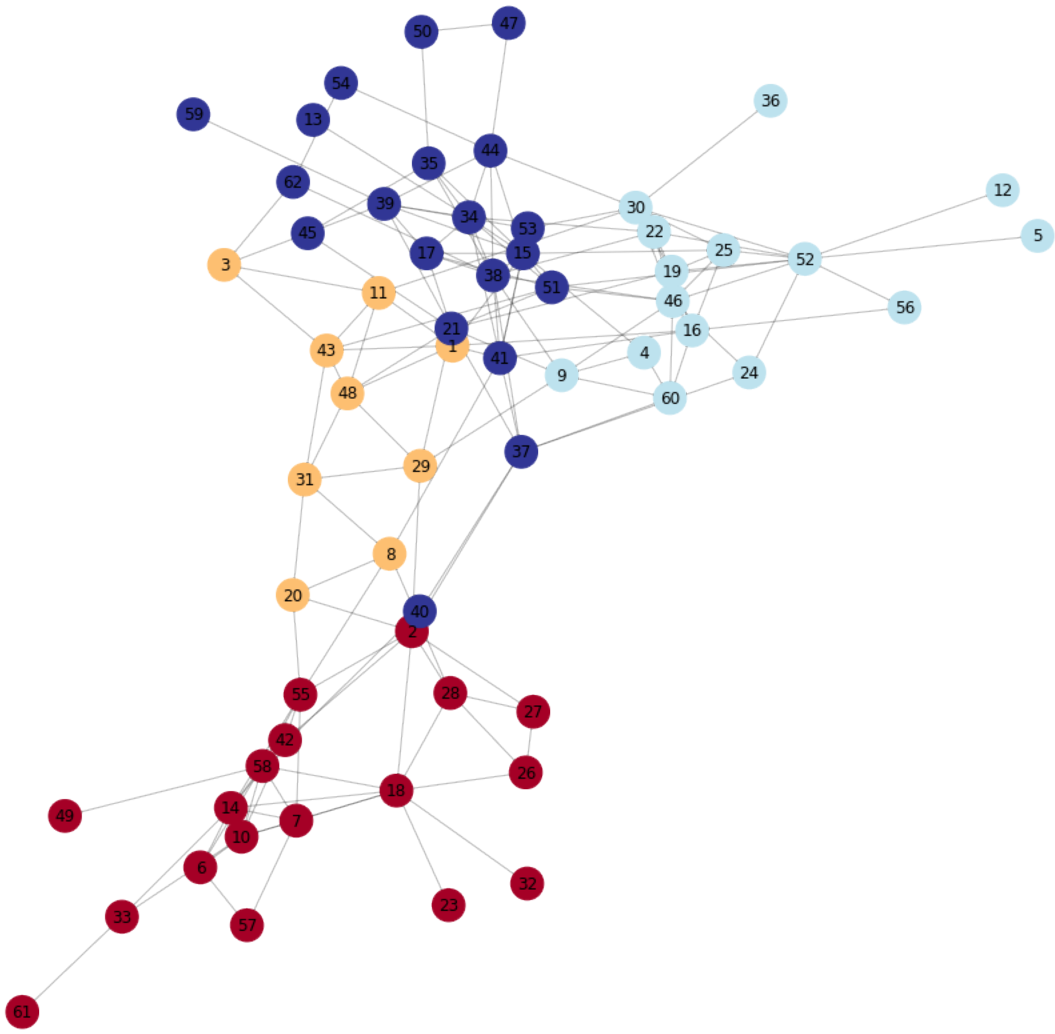

Figure 20: Community Detection

3.9.1 Interpretation:

We observe about four (communities)

- Blue Community: Contains 20 dolphins.
  15(Grin) with degree 12 (possibly the leader)
  38 (SN4) with degree 11

- Red Community: Contains 18 dolphins.

10 (Trigger) with degree 10 (possibly the leader)

9 (Web) with degree 9

- Sky blue Community: Contains 15 dolphins.

  46 (Topless) with degree 11 (possibly the leader)

  30 (Patchback) with degree 10

- Yellow Community: Contains 9 dolphins.

  43 (SN96) and 48 (TR77) both have degree 6

- Node 37 (SN100) who has the highest closeness and betweenness degree has a degree of just 7. Observe that SN100 does not have the highest number of direct interaction even in his own community (Blue Community). Yet he is a very important Dolphin in spreading information (possibly diseases) to other dolphins.
- The nodes with degree 1 are possibly baby dolphins who stick close to just their mother. Like nodes 5,12,23,32, 36, 49, 59, 61.
- If the above assumption is true, then nodes 18,30,33,39,52 and 58 are possibly mother dolphins defended by the male dolphins possibly for mating.
- This could explain why the Red community is the most populated. Since the community has more mother dolphins (18, 33 and 58), more males and baby dolphins will tend to surround them.

4 Conclusion

Indeed our Dolphine Network reflects reality as it follows most behavioural patterns of dolphins such as mating, birth rate of females and territoriality.

5 References

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