NETWORK SCIENCE

Assignment 6

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1 Question 1

I used this code snippet to create and plot the graph

```
graph1 <- erdos.renyi.game(30, 0.17)
plot(graph1,vertex.label=NA)
```
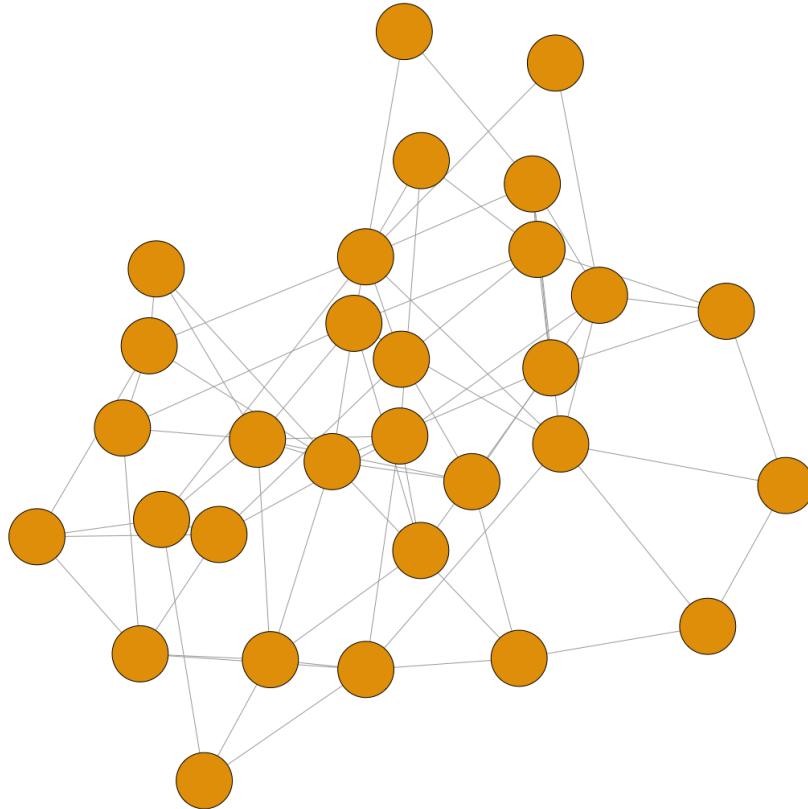

Figure 1: Network plot of Question 1

2 Question 2

2.1

```
print(ecount(graph1))
# output: 73
```

2.2

```
deg_dist <- degree(graph1)
#deg_dist: 5 5 5 2 2 4 4 7 6 3 4 5 4 4 6 3 5 8 3 3 5 3 6 6 7 6 4 6 7 8
```

2.3

```
hist(deg_dist, col="orange")
```

Histogram of deg_dist
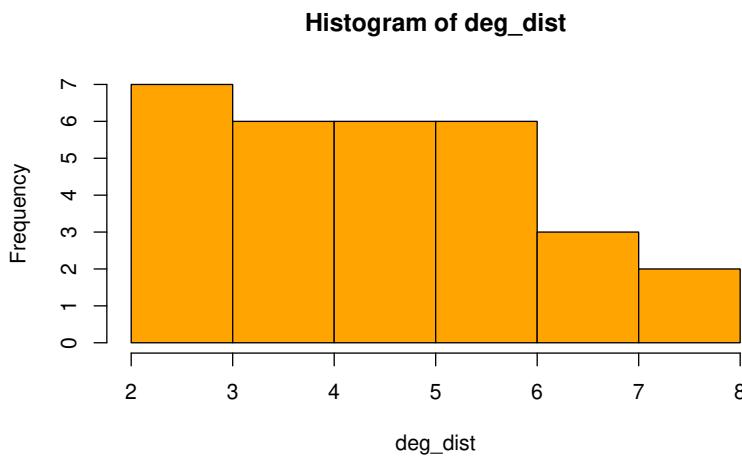
Figure 2: Question 2c: histogram of degree distribution

2.4

```
graph.density(graph1)
# output: 0.168
```

3 Question 3

3.1

Creating graph2 with edge probability of 0.5:

```
graph2 <- erdos.renyi.game(30, 0.5)
```

Calculating the density of graph2

```
graph.density(graph2)
# output: 0.471
```

3.2

Graph1 has a higher density compared to graph1.

3.3

Density tells us the ratio between the edges present in a graph and the maximum number of edges that the graph can contain. This is somehow also the definition of the probability of existing an edge between nodes. So, when we increase this probability when creating the graph, the density also increases to match that number.

3.4

```
graph2 <- erdos.renyi.game(100, 0.5)
graph.density(graph2)
# output: 0.512
```

No there is not any significant change in density of the graph. As I mentioned in the last section, the density of the graph is a number close to p. As we increase the number of nodes, the density becomes closer to p. If we increase number of edges enough, the density and p will be equal.

4 Question 4

The plot is shown in figure 3. I did not remove the labels because it is not possible to track the random walk without the labels.

```
graph1_pa <- sample_pa(30)
plot(graph1_pa, edge.arrow.size=0.2)
```
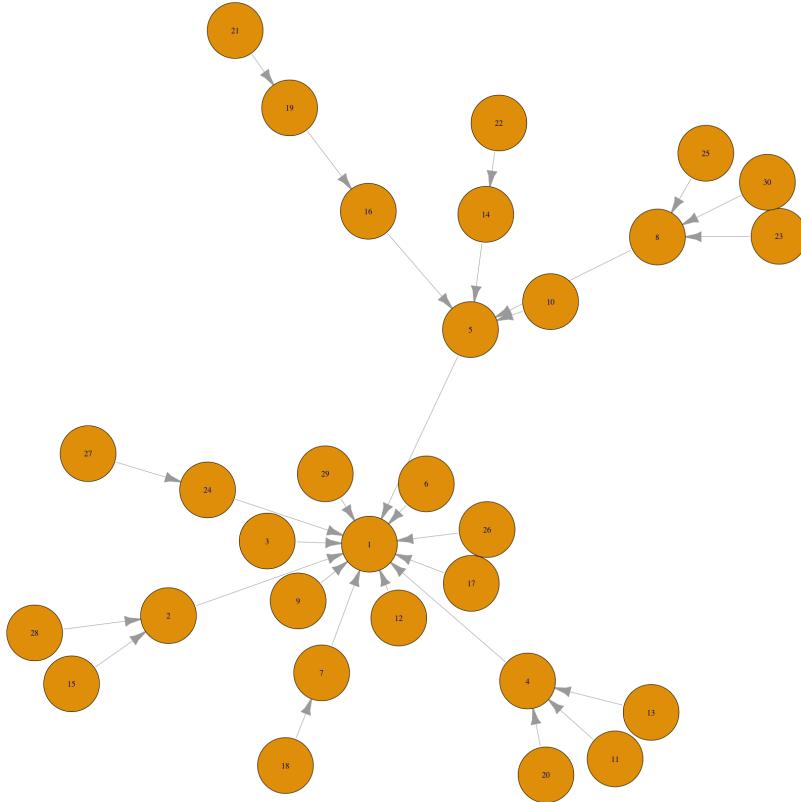

Figure 3: Question 4: graph with preferential attachment

4.1

```
graph.density(graph1_pa)
# output: 0.0333
```

The density of graph1_pa is less than the other two. The sample_pa function starts building the graph by adding nodes one by one. When adding a new node to the graph, the nodes that already have more degree are more probable to be connected to the new node. So, there would be just a few nodes with lots of edges and most of the nodes have very a few edges connected to them. Because most of the edges have very few edges connected to them, the density of the graph will not be a large number.

4.2

The graph is directed, so it is possible to pass the edges in only one direction. because the random walk starts at node 1, and all the edges connecting to 1 are toward 1, we cannot go anywhere from node 1. So, I changed the mode in random_walk function so that it traverses the edges in opposite direction.

```
w <- random_walk(graph1_pa, start = 1, steps = 8,   mode = c("in"))
# w: 1 2 28
```

Although the number of steps is 8, the output is 1 2 28. because there is not any path to take from node 28.

4.3

```
graph2_pa <- sample_pa(30,3)
plot(graph2_pa, edge.arrow.size=0.2)
```
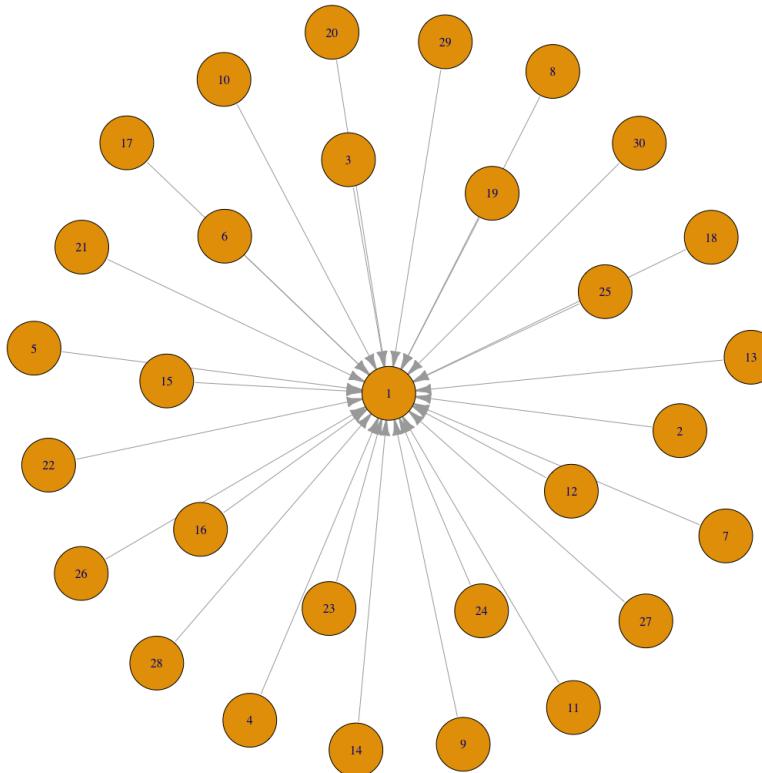

Figure 4: Question 4.4: graph with preferential attachment 2

4.4

It does not change the density. We are increasing "the rich get richer" effect by increasing the power in the function. It does not change the number of total edges. It changes the way edges are distributed beween nodes.

```
graph.density(graph1_pa) #0.0333
graph.density(graph2_pa) #0.0333
```