1. First, perform the Kevin Bacon Hollywood Actor exercise on the venture capital firm network.

(A) Which firm is the center of the venture capital firm network as of July 2014? Consider the most central firm to be the firm with the largest closeness centrality, as in the Hollywood Actor example.

We first need to get the edge list. As of July 2014, any unique Investment partnership between two firms is considered as an edge. Once we get the edge list, closeness centrality is calculated using the igraph function closeness()

```
which.max(closeness(p_1))
```

```
Intel Capital
            4
```

(B) Next, compute the average shortest path length between all firms in the July 2014 network and verify that the firm with the highest closeness centrality also has the lowest average path distance. You can consider nodes that are unreachable to be separated by a number of steps equal to the total number of the firms in the network.

Average lowest path distance is calculated using the function

```
which.min((rowSums(distance_p_1_2)))
```

This is found to be

```
Intel Capital
            4
```

Hence we can verify that our answer is correct as Intel Capital has both the max closeness centrality and lowest average path distance

(C) What is the average shortest path length for all firms? Why is this number so high?

The average shortest path length for all firms is calculated using

```
Mean(rowMeans(distance_p_1_2))
```

```
 [1] 969.5711
```

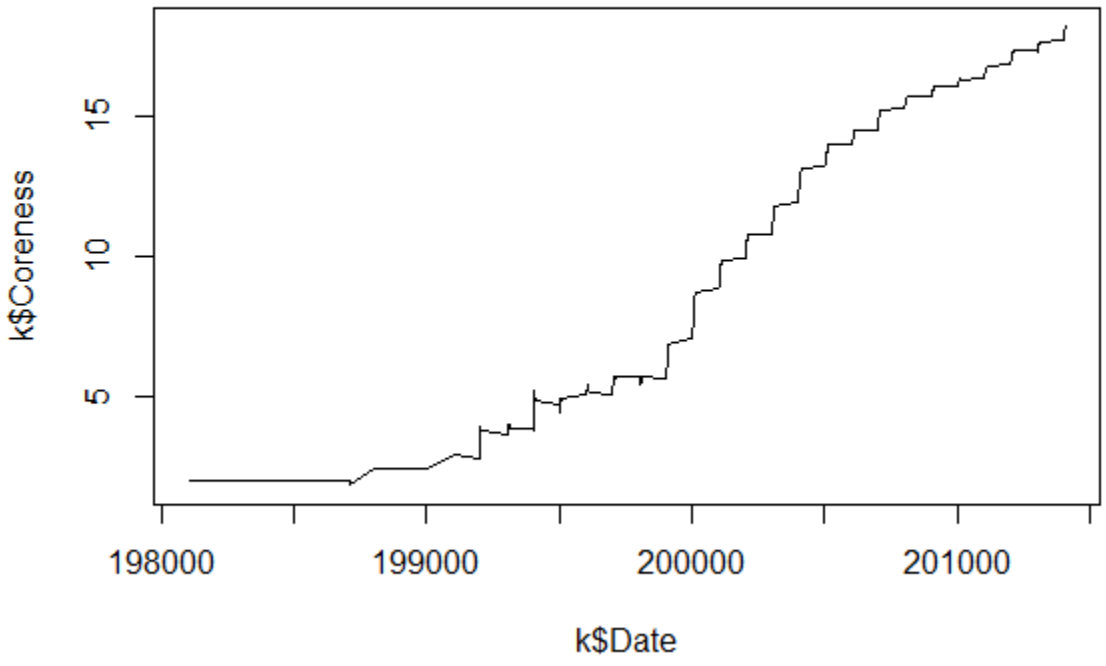
It is large because the Venture capital network has a large number of players and from the graph, we can observe that there a large number of disconnected subgraphs and there is a tendency to form a core-periphery network. The path length was assumed to be number of firms for unreachable nodes.

2. Next, we will look at the development of the network over time. Allow the network to be updated monthly for each month t in the data, adding the new ties that occur through investments in the current month to be added to the existing network of ties that have occurred in previous months. In Class Session 3, a figure plotted the average “coreness” of the venture capital network over time. Coreness represents the highest-degree k-core to which a firm belongs. When a node is a member of a k-core

with a high degree, its surrounding ties are very dense. When many nodes are members of k-cores with high degrees, this suggests that there may exist dense clusters within the network.

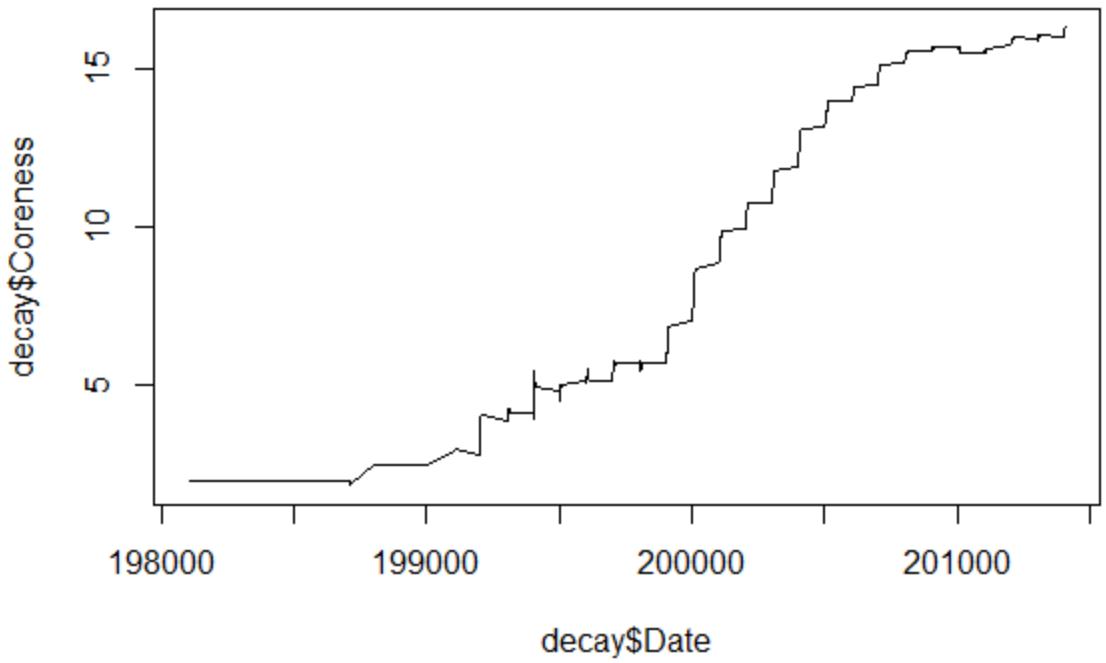
(A) Construct a figure similar to Class Session 3's, plotting the average "coreness" of firms in the network over time. This can be computed using the igraph function coreness. On the x-axis should be the age of the network in months. On the y-axis should be the highest-degree k-core each venture capital firm belongs to, averaged over all firms in the network up to that month.

All the months where a deal was made was included in the month index. A cumulative edge list was calculated and the graph was plotted for each month



We can see that the coreness increases steadily over time

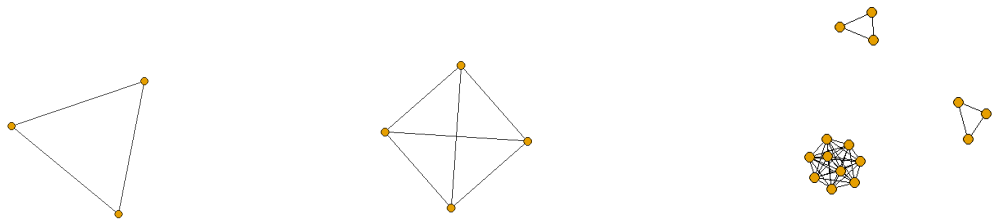
(B) Construct a plot similar to (A), but now allow ties to "decay." Remove ties from the network if they are not renewed within 10 years. Does the figure appear different than before? What does this suggest about the nature of relationships in the co-investment network?



There is a very slight difference we observe between the Decay graph and the Cumulative ties graph. In the decay graph, the coreness seems to flatten out for recent years whereas it is continuously rising for the Cumulative ties graph. This might be due to old ties not being renewed, the average number of k-cores that each node belongs to has reduced in recent years.

3. Continuing to look at the development of the venture capital over time, do you think that the recent network now exhibits more of a core-periphery structure or a structure made up of distinctly clustered components? Provide at least two pieces of descriptive evidence for your conclusion.

Let us try to visualize how the Venture capital network has evolved over time



We can clearly see how the network has slowly evolved into a core-periphery network.

Other descriptive statistics can be used like transivity and walktrap can be used

```
cluster_walktrap(p_graph_2, steps=10)
```

```
IGRAPH clustering walktrap, groups: 1364, mod: 0.33
+ groups:
  $`1`
  [1] "Confluence Capital Partners"   "NEW Capital Fund"
  [3] "Wisconsin Investment Partners" "Venture Management LLC"
  [5] "Peak Ridge Capital Group"      "Phenomenelle Angels"
  [7] "Rosetta Partners"

  $`2`
  [1] "Fulcrum Equity Partners"       "JP Charter Oak Advisors"
  [3] "WRD Capital"                   "Ad Pepper Media International"
  [5] "Brand Affinity Technologies"   "RimLight Capital"
  + ... omitted several groups/vertices
> transitivity(p_graph_2)
[1] 0.1295827
```

The low clustering coefficient and relatively large number of clusters formed even for a high step parameter indicates that the Venture Capital network has more of a core periphery structure than a small world kind of structure

4. Last, we will analyze whether being in the core of the network helps venture capital firms' and the entrepreneurs they work with to perform better. You may use whichever statistical approach you wish to determine the direction and strength of the relationship between network position and a venture capital firm's performance.

(A) Is a venture capital firm being at the center of the network related to having more more successful investments in a given year, in terms of its closeness centrality? Is this true for other kinds of centrality as well?

Let us create a table with the average successes in a year of each Venture capital firm along with different measures of their centralities like closeness,degree and betweenness.

We observe the following correlations

```
> cor(success_table$successful_investments_avg,success_table$closeness)
[1] 0.2937021
> cor(success_table$successful_investments_avg,success_table$degree)
[1] 0.3719713
> cor(success_table$successful_investments_avg,success_table$betweenness)
[1] 0.1204403
```

We can say that Venture capital firms more central in the network tend to be more successful

(B) Is a venture capital firm being at the center of the network related to being less likely to go out of business, in terms of its closeness centrality? Is this true for other kinds of centrality as well?

Similar to A, let us observe the correlations of centrality with tendency to go out of business.

```
> cor(success_table$failed,success_table$closeness)
[1] -0.1033834
> cor(success_table$failed,success_table$degree)
[1] -0.1422215
> cor(success_table$failed,success_table$betweenness)
[1] -0.06770204
```

We can see a negative correlation which implies that firms more central in the network are less likely to go out of business.