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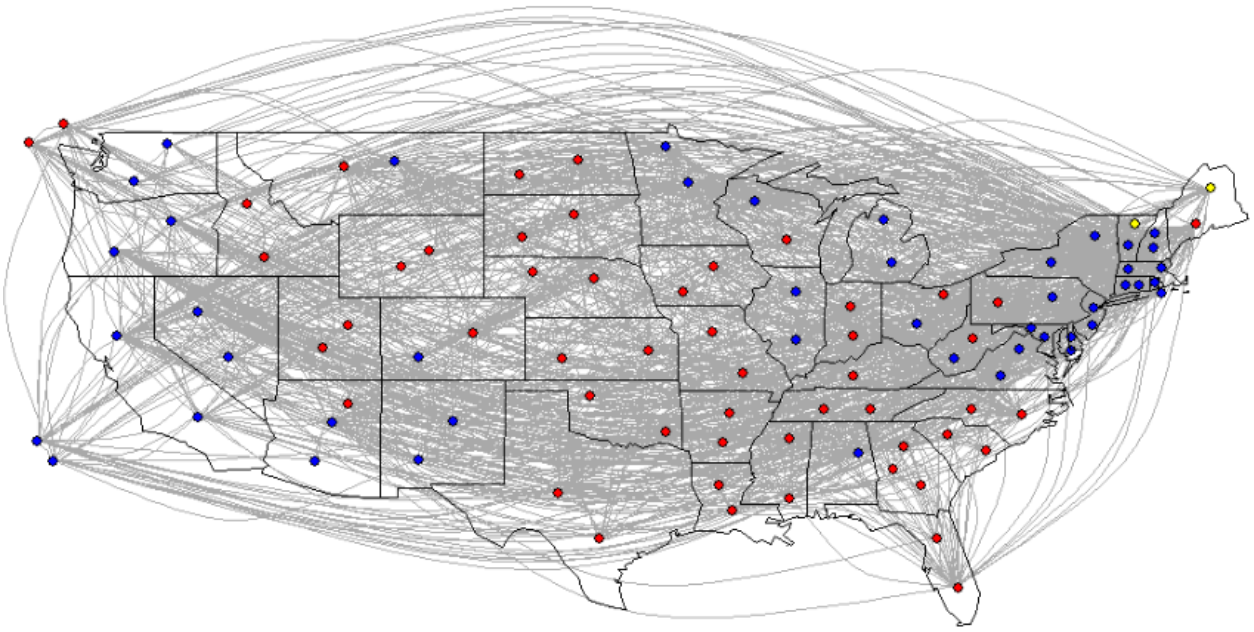
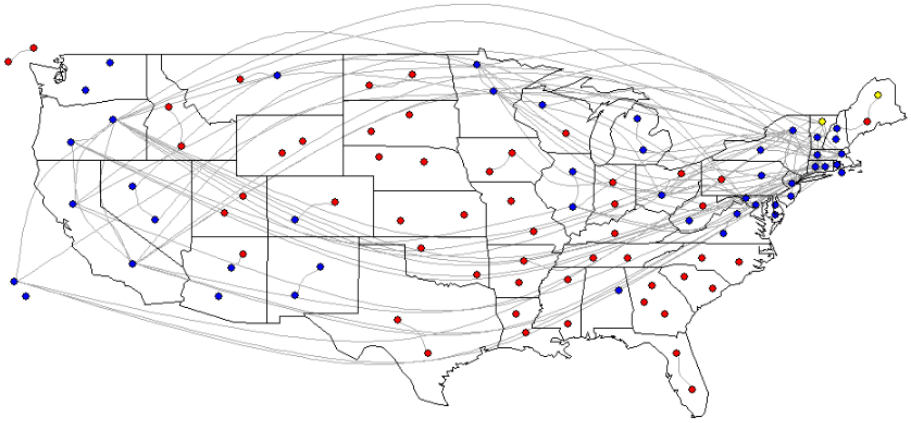
15.071
HW #7

PROBLEM 1A



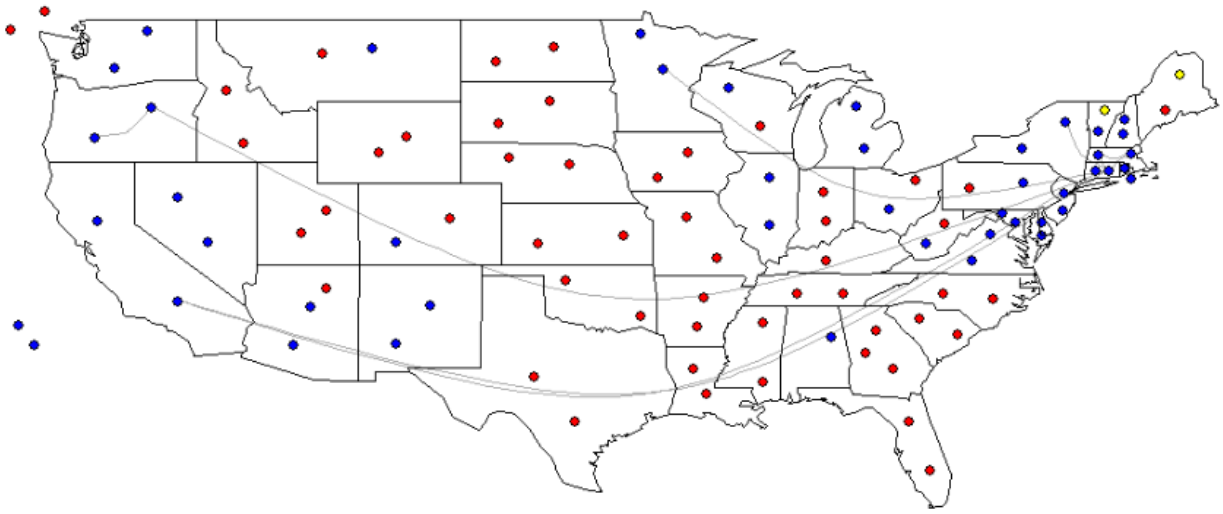
As expected, Democratic senators typically come from the west coast and northeast while Republican senators typically come from the south / southeast and Midwest of the country. This is because you typically find Democratic voters in the large coastal cities like L.A., SF, NYC, and Boston while Republican voters tend to be found in less densely populated areas across the south and Midwest.

PROBLEM 1B



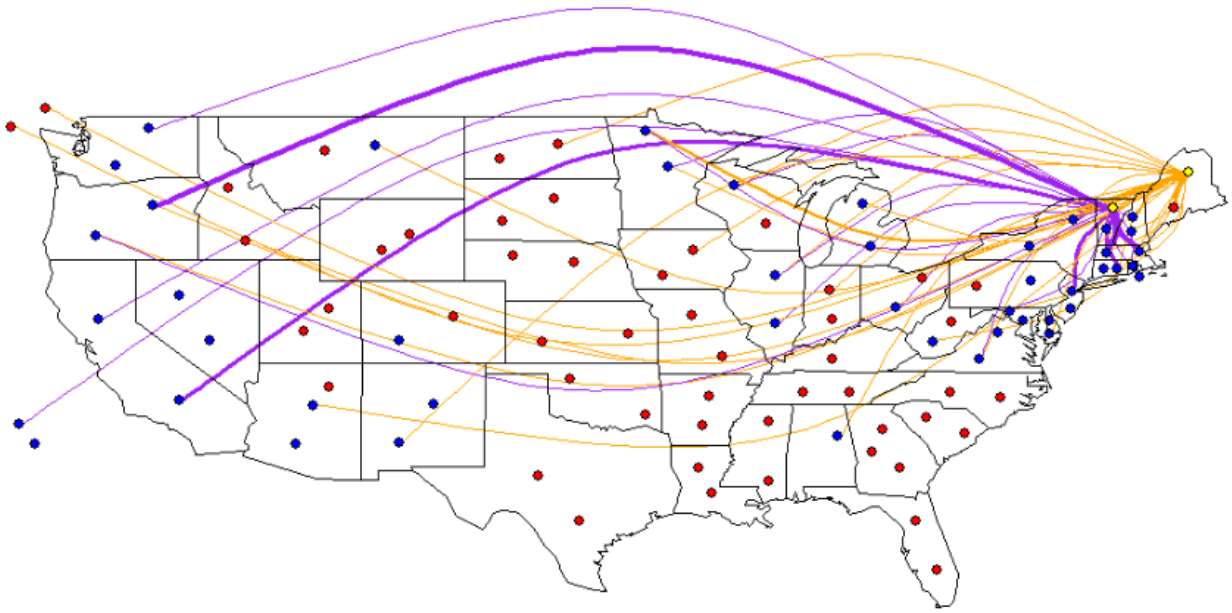
The above graph has a threshold of n = 30. One of the first interesting observations is that senators from blue states are more likely to co-sponsor bills with other senators than red states. You can see the

number of connections between blue dots in this chart, but very few between red dots. The reason for this might be that the Republicans had a majority in the senate for this dataset. Therefore, the Democrats might have felt the need to co-sponsor bills as a way to show unity and push their ideas through the Republican majority.



This chart was set at a threshold of n = 70. Another interesting observation is that there are a number of co-sponsorships across states e.g., west coast states with east coast states, but fewer co-sponsorships within a state. Interestingly, the senators from Oregon were on the same page frequently – one of the few (maybe only) states with this high of a co-sponsorship rate between senators from the same state.

PROBLEM 1C



There are a few interesting observations from this chart.

First, we see that the independent senator from Maine mostly has connections with Republican senators from other states. This is no surprise given the other senator in Maine is a Republican. This tells us that although the senator is Independent, they likely have a Republican leaning in their politics and policies they back.

Similarly, we see that the independent senator from Vermont mostly has connections with Democratic senators from other states. This is no surprise given the other senator in Vermont is a Democrat. This tells us that although the senator is Independent, they likely have a Democratic leaning in their politics and policies they back.

PROBLEM 1D

Calculating centrality figures

```
# Calculate degree centrality
dg = degree(sg)
sg.Senators$degree <- dg

# Calculate closeness centrality
cl = closeness(sg)
sg.Senators$closeness <- cl

# Calculate betweeness
bn = betweenness(sg)
sg.Senators$betweeness <- bn
```

<u>Senators with top 10 degree of centrality</u>

```
> head(sg.Senators[order(sg.Senators$degree, decreasing = TRUE),], 10)
     id              name state party          x        y degree   closeness betweeness quotient clust
53   53      Amy Klobuchar    MN     D  -94.17185 46.52615     56 0.006756757  228.46469 4.079727     2
88   88         Tina Smith    MN     D  -95.26519 48.27262     52 0.006666667  162.18280 3.118900     2
19   19      Susan Collins    ME     R  -69.57167 44.51100     51 0.006666667  132.81845 2.604283     3
6     6 Richard Blumenthal    CT     D  -72.34624 41.55773     50 0.006535948  123.27626 2.465525     2
39   39    Margaret Hassan    NH     D  -71.53721 44.09488     49 0.006578947  102.88327 2.099659     3
98   98   Elizabeth Warren    MA     D  -72.83165 42.32477     47 0.006369427   62.05448 1.320308     2
20   20  Christopher Coons    DE     D  -75.60370 38.39383     46 0.006451613  124.92085 2.715671     3
96   96   Chris Van hollen    MD     D  -77.52402 39.49261     45 0.006289308   47.78719 1.061938     2
101 101          Ron Wyden    OR     D -121.97770 43.19769     45 0.006024096   91.53141 2.034031     2
32   32   Dianne Feinstein    CA     D -121.81547 39.14369     44 0.006172840   60.71637 1.379918     2
```

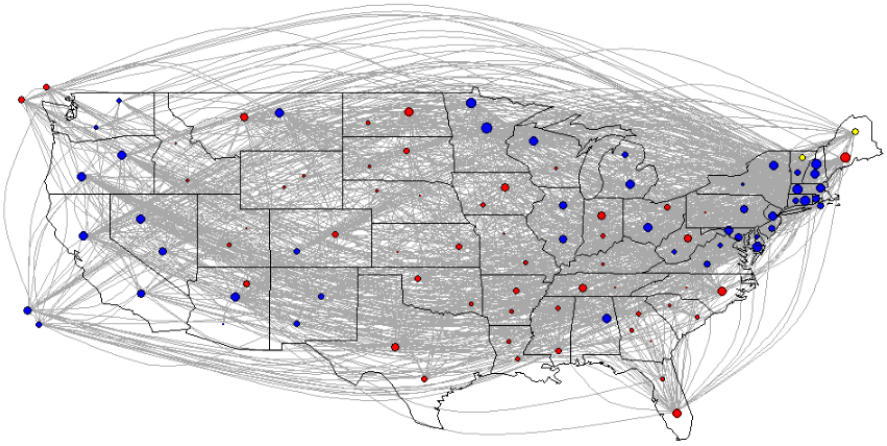
<u>Senators with top 10 closeness centrality</u>

```
> head(sg.Senators[order(sg.Senators$closeness, decreasing = TRUE),], 10)
   id              name state party         x        y degree   closeness betweeness quotient clust
53 53      Amy Klobuchar    MN     D -94.17185 46.52615     56 0.006756757  228.46469 4.079727     2
19 19      Susan Collins    ME     R -69.57167 44.51100     51 0.006666667  132.81845 2.604283     3
88 88         Tina Smith    MN     D -95.26519 48.27262     52 0.006666667  162.18280 3.118900     2
39 39    Margaret Hassan    NH     D -71.53721 44.09488     49 0.006578947  102.88327 2.099659     3
6   6 Richard Blumenthal    CT     D -72.34624 41.55773     50 0.006535948  123.27626 2.465525     2
20 20  Christopher Coons    DE     D -75.60370 38.39383     46 0.006451613  124.92085 2.715671     3
48 48         Doug Jones    AL     D -85.88179 33.44027     42 0.006410256  103.28284 2.459115     1
98 98   Elizabeth Warren    MA     D -72.83165 42.32477     47 0.006369427   62.05448 1.320308     2
78 78        Marco Rubio    FL     R -81.10930 26.98167     41 0.006329114  325.48986 7.938777     1
96 96   Chris Van hollen    MD     D -77.52402 39.49261     45 0.006289308   47.78719 1.061938     2
>
```

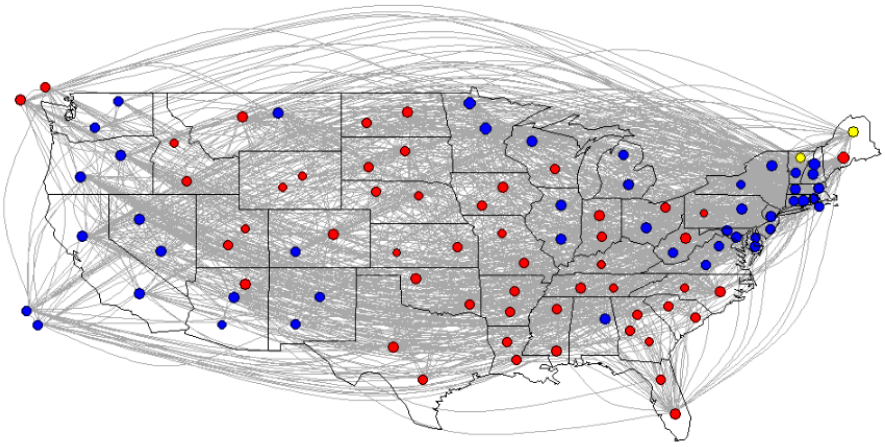
Senators with top 10 betweeness

```
> head(sg.Senators[order(sg.Senators$betweeness, decreasing = TRUE),], 10)
   id              name state party         x        y degree   closeness betweeness quotient clust
78 78      Marco Rubio    FL     R  -81.10930 26.98167     41 0.006329114   325.4899 7.938777     1
53 53    Amy Klobuchar    MN     D  -94.17185 46.52615     56 0.006756757   228.4647 4.079727     2
5   5 Marsha Blackburn    TN     R  -87.60523 35.56603     34 0.006097561   225.7828 6.640671     1
24 24     Kevin Cramer    ND     R  -99.51486 47.63509     39 0.006250000   194.0737 4.976248     1
10 10       Mike Braun    IN     R  -86.30604 40.52763     33 0.005988024   169.7993 5.145432     1
88 88         Tina Smith    MN     D  -95.26519 48.27262     52 0.006666667   162.1828 3.118900     2
27 27      Steve Daines    MT     R -110.84405 47.28107     36 0.006134969   157.3378 4.370494     1
31 31       Joni Ernst    IA     R  -92.92207 42.46009     37 0.006172840   156.4261 4.227732     1
93 93    Thomas Tillis    NC     R  -77.98822 35.32976     38 0.006250000   145.6314 3.832404     1
87 87   Kyrsten Sinema    AZ     D -111.41824 34.94484     39 0.006250000   143.5341 3.680361     1
```

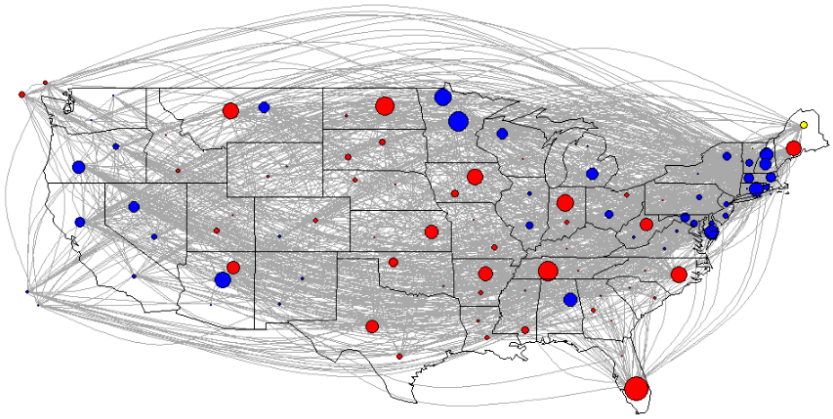
Map of degree of centrality (larger circle = higher degree of centrality)



Map of closeness centrality (larger circle = larger closeness centrality)



Map of betweeness (larger circle = higher betweeness)



Takeaways:

- Amy Klobuchar is either #1 or #2 in all the centrality measures. She is often seen as a moderate Democrat. Given the Democrats had the minority, adding Sen. Klobuchar to many of these bills might have been a political strategy to get the Republicans to the bargaining table. My guess is they are more apt to listen to her vs. someone who is more liberal.
- For degree of centrality and closeness, most of the top senators in the list are Democratic. Not unexpected given what we said earlier about Democrats likely needing to band together for support given they had a minority senate position.
- However, for betweenness we see many more Republicans show up on the list. And surprisingly the senator with the highest betweenness score is Marco Rubio – a Republican. Much like Sen. Klobuchar, Sen. Rubio is seen more as a centrist and likely worked more closely with Democrats than his Republican colleagues were willing to do.
- Lastly, the betweenness chart shows how betweenness differs between senators in a specific state. States typically have a senior and junior senator. So likely the more senior senator - who has been in the senate longer – has a higher betweenness score.

PROBLEM 1E

```
# calculate quotient of betweeness centrality divided by degree of centrality
sg.Senators$quotient <- sg.Senators$betweeness / sg.Senators$degree

# Senators with top 10 betweeness divided by closeness
head(sg.Senators[order(sg.Senators$quotient, decreasing = TRUE),], 10)
```

```
> head(sg.Senators[order(sg.Senators$quotient, decreasing = TRUE),], 10)
   id             name state party          x        y degree   closeness betweeness quotient
78 78      Marco Rubio    FL     R  -81.10930 26.98167     41 0.006329114   325.4899 7.938777
5   5 Marsha Blackburn    TN     R  -87.60523 35.56603     34 0.006097561   225.7828 6.640671
64 64       Jerry Moran    KS     R  -96.05998 38.44235     18 0.005434783   101.6930 5.649612
23 23        Tom Cotton    AR     R  -92.14113 35.42359     21 0.005263158   116.5119 5.548184
10 10        Mike Braun    IN     R  -86.30604 40.52763     33 0.005988024   169.7993 5.145432
24 24     Kevin Cramer    ND     R  -99.51486 47.63509     39 0.006250000   194.0737 4.976248
27 27     Steve Daines    MT     R -110.84405 47.28107     36 0.006134969   157.3378 4.370494
31 31       Joni Ernst    IA     R  -92.92207 42.46009     37 0.006172840   156.4261 4.227732
53 53    Amy Klobuchar    MN     D  -94.17185 46.52615     56 0.006756757   228.4647 4.079727
93 93    Thomas Tillis    NC     R  -77.98822 35.32976     38 0.006250000   145.6314 3.832404
>
```

This metric normalizes the betweenness centrality by the number of people the senator is connected with (e.g., the degree of centrality). Someone might have a high betweenness simply because they are connected to a lot of people – perhaps because they have been in the senate a long time. However, we want to identify the right balance of betweenness and degree of centrality. In other words, we want to identify the people that still have a high betweenness i.e., a lot of shortest paths flow through them, but don't rely on just knowing a lot of people. We might use this metric to identify the "arbitrators" in Congress i.e., the people that are being put to work to try to work across the aisle to get things accomplished. Or perhaps the "power brokers" because info flows through them and they are heavily connected to others.

PROBLEM 1F

```
# create communities
set.seed(173)
community = cluster_spinglass(sg, spins = 100, weights = E(sg)$n)
head(community)

# get community information
clust = community$membership #extract community assignments
table(clust)
```

```
> table(clust)
clust
 1  2  3  4  5
48 31 18  1  2
```

We find a total of 5 communities. In community 1 there are 48 members, in community 2 there are 31 members, in community 3 there are 18 members, in community 4 there is 1 members, and community 5 has 2 members.

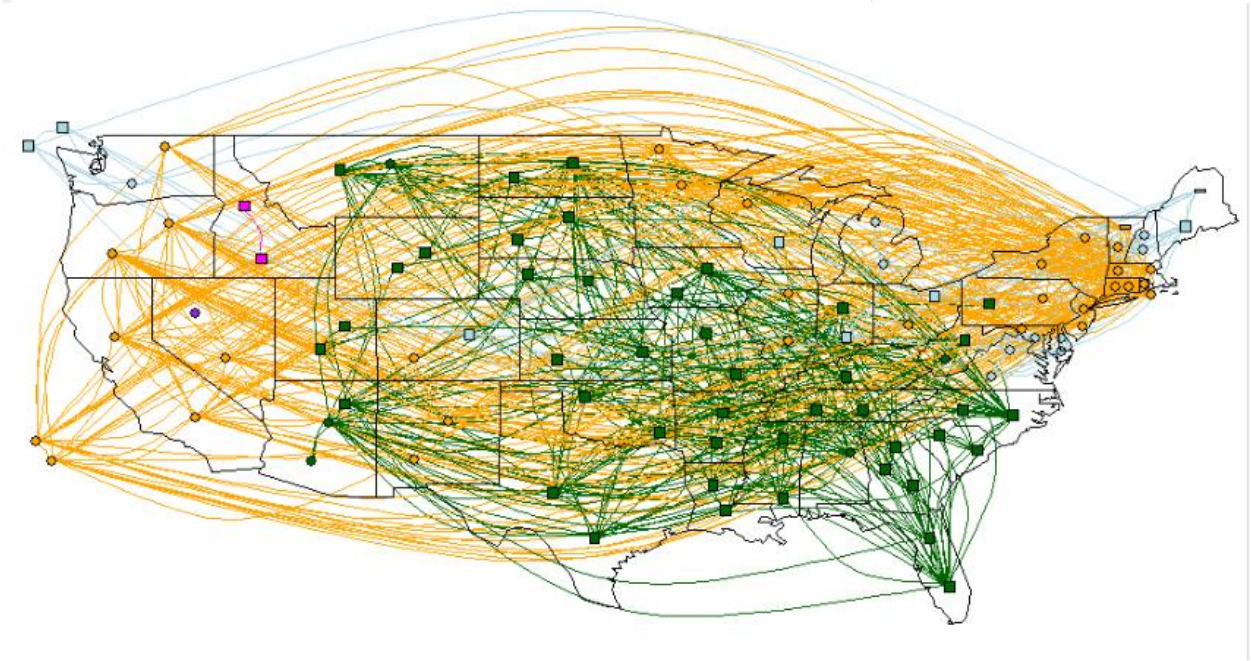
```
> community$modularity
[1] 0.03623698
```

Calculating the community modularity, we get a value of 0.03623698.

PROBLEM 1G

```
# Plot

plot(sg,
     vertex.size = 50, # you can modify this so that the points are visible
     vertex.label=NA, # don't plot the Senator's names next to each vertex
     vertex.shape=recode(V(sg)$party,"R"="square","D"="circle", "I"="rectangle"), # assign vertex shapes by party
     vertex.color=clrs[sg.Senators$clust], # assign vertex color by community
     edge.lty = ifelse(E(sg)$c1 == E(sg)$c2, "solid", "blank"), # only show edges within the same community
     edge.color = clrs[E(sg)$c1], # edge color by community
     edge.curved = TRUE, # make the edges curved
     layout = cbind(V(sg)$x,V(sg)$y), # plot each Senator in their state
     rescale=FALSE, # fix the plot axes to the co-ordinate scale
     xlim = range(senators$x), ylim = range(senators$y) # fix the upper/lower bounds of the plot
)
maps::map("state",  add=TRUE, col="black") # add a map of the US states
```



PROBLEM 1H

The below table shows the number from each party in each community:

```
> table(sg.Senators$party, clust)
   clust
     1  2  3  4  5
  D  5 30 10  1  0
  I  0  1  1  0  0
  R 43  0  7  0  2
```

PROBLEM 1I

Looking at the below table, we find the following states have senators in different communities:

- Colorado
- Indiana
- Maryland
- Nevada
- Ohio
- Pennsylvania
- Washington
- Wisconsin

So in total, there are 8 out of 50 states with senators in different communities.

```
> table(sg.Senators$state, clust)
    clust
     1 2 3 4 5
  AK 0 0 2 0 0
  AL 1 0 0 0 0
  AR 2 0 0 0 0
  AZ 3 0 0 0 0
  CA 0 2 0 0 0
  CO 0 1 1 0 0
  CT 0 2 0 0 0
  DE 0 0 2 0 0
  FL 2 0 0 0 0
  GA 3 0 0 0 0
  HI 0 2 0 0 0
  IA 2 0 0 0 0
  ID 0 0 0 0 2
  IL 0 2 0 0 0
  IN 1 0 1 0 0
  KS 2 0 0 0 0
  KY 1 0 0 0 0
  LA 2 0 0 0 0
  MA 0 2 0 0 0
  MD 0 1 1 0 0
  ME 0 0 2 0 0
  MI 0 0 2 0 0
  MN 0 2 0 0 0
  MO 2 0 0 0 0
  MS 2 0 0 0 0
  MT 2 0 0 0 0
  NC 2 0 0 0 0
  ND 2 0 0 0 0
  NE 2 0 0 0 0
  NH 0 0 2 0 0
  NJ 0 2 0 0 0
  NM 0 2 0 0 0
  NV 0 1 0 1 0
  NY 0 2 0 0 0
  OH 0 1 1 0 0
  OK 2 0 0 0 0
  OR 0 2 0 0 0
  PA 1 1 0 0 0
  RI 0 2 0 0 0
  SC 2 0 0 0 0
  SD 2 0 0 0 0
  TN 2 0 0 0 0
  TX 2 0 0 0 0
  UT 2 0 0 0 0
  VA 0 0 2 0 0
  VT 0 2 0 0 0
  WA 0 1 1 0 0
  WI 0 1 1 0 0
  WV 2 0 0 0 0
  WY 2 0 0 0 0
```

PROBLEM 1J

Cluster 1 is largely Republican. Based on the chart from problem 1G we find that most of the cluster 1 senators are located in the central and southern parts of the country. This is no surprise given this is where most of the Republican senators are coming from anyway. In cluster 1 we see that the 5 Democrats come from states that have a Republican senator including Arizona, West Virginia, Alabama, and Wyoming. This might suggest that although the senator might have a different party affiliation (Democrat), in practice they might be more likely to co-sponsor bills coming from the Republican party given pressure from either their fellow senator of from the will of the people of their state.

Cluster 2 falls along similar party lines. We see cluster 2 pops up in the northeast and west coast, areas that are Democrat strongholds. Unsurprisingly there are no Republicans in this cluster, suggesting this group might be a strongly Democratic agenda which is unlikely to attract co-sponsorship from Republicans.

Interestingly, of the 8 states that have senators in different clusters there is only 1 state – Pennsylvania – where one senator is in cluster 1 and the other in cluster 2. This again suggests strong policy differences between cluster 1 and 2 (driven by specific policy support by voters).

Cluster 3 is interesting because it has a more equal split between Democrats and Republicans. This is interesting because these clusters appear in some of the typical presidential election swing states e.g., Ohio, Michigan, and Virginia. What this might suggest is the ideology of cluster 3 is more moderate or centrist and includes senators that are more likely to work with and consider the other side.

Cluster 4 is one Democrat in Nevada. Perhaps this person is very new or they have very unique politics that they are unlikely to be similar to any other senator clusters.

Lastly Cluster 5 includes the 2 Republican senators from Idaho. Similar to cluster 4, these senators might have a lot in common with each other, but less with the broader Republican party. Some of this might be due to geography and them being disconnected from the core of the Republican base in midwestern and southern America.