Complex Networks

Programming Assignment 1

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In [9]:
```r
### Small bit of code to produce results that follow

packages = c('testit', 'network', 'sna', 'scales')
for(package in packages) {
    suppressMessages(
        library(package, character.only = TRUE))
}
source("assignment1_functions.R"); # lecturer provided

# These ones are provided as an appendix
source("my_functions.R");
source("tests.R");
source("process_adj_matrices.R"); # load up the networks
```

```
[1] "Tests pass"
```

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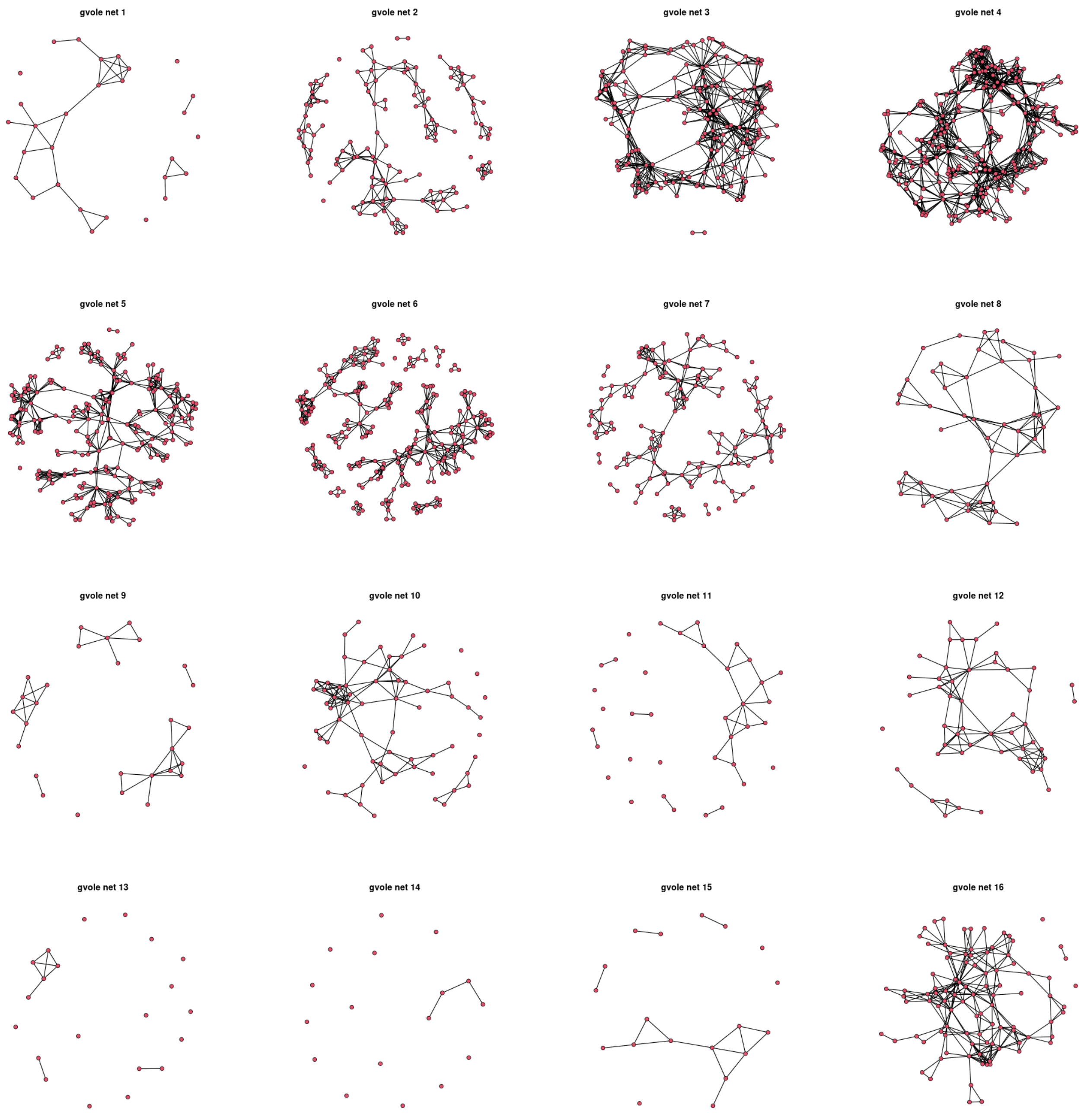
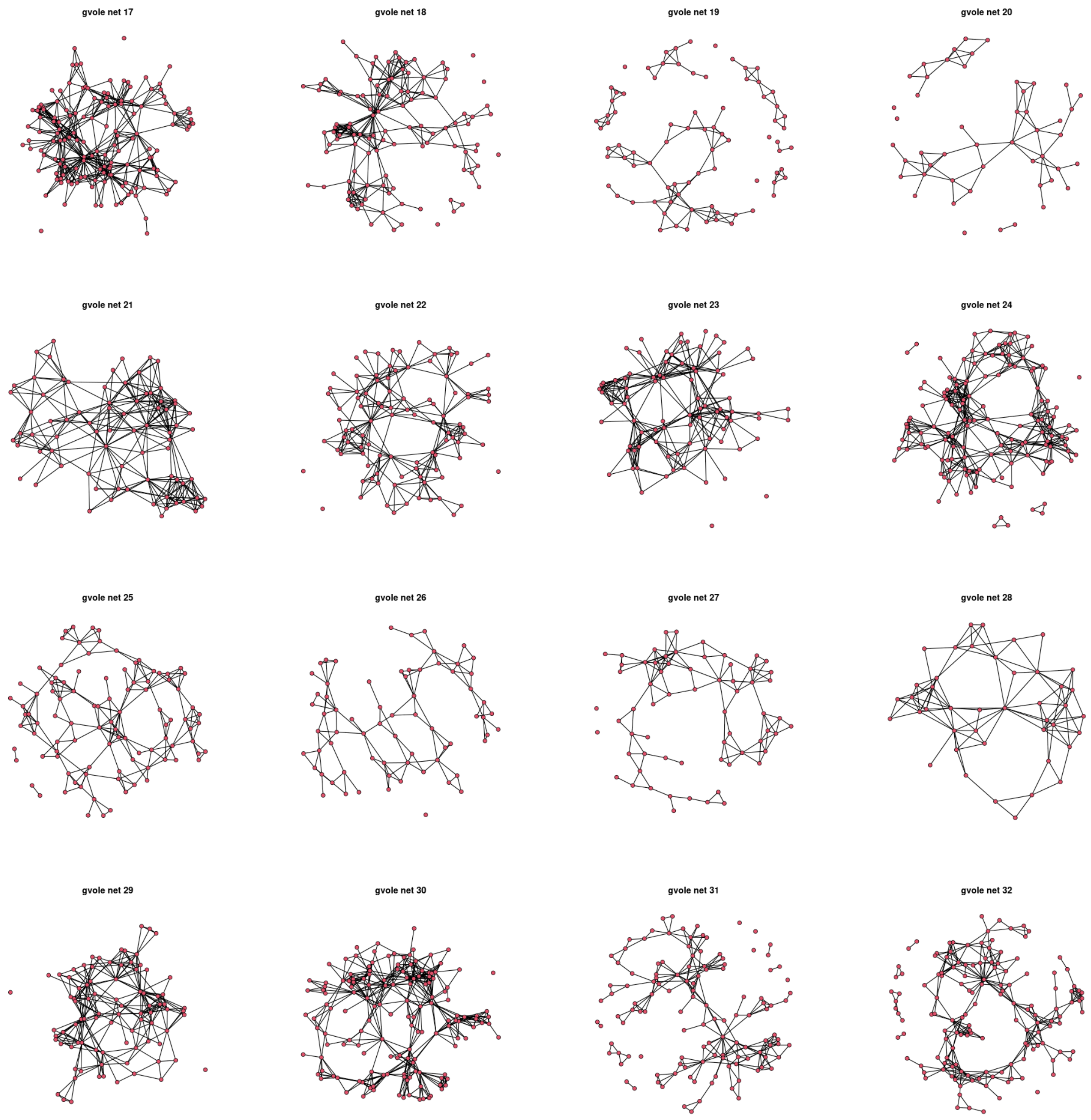
Question 1

In [10]:
```
plotAllNetworks(networks);
# Genereate the grid with a bash script, seems easier than R
# system("./makeGrid.sh");
```




gvole net 17
gvole net 18
gvole net 19
gvole net 20
gvole net 21
gvole net 22
gvole net 23
gvole net 24
gvole net 25
gvole net 26
gvole net 27
gvole net 28
gvole net 29
gvole net 30
gvole net 31
gvole net 32

Question 2

In the table, let "lc" be longest component

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```
In [3]: data = getDataForAllNetworks(networks);
        data
```

A data.frame: 32 × 7

	net_id	nodes	edges	components	lc_node_share	avg_degree	avg_path_length_lc
	<int>	<dbl>	<int>	<int>	<dbl>	<dbl>	<dbl>
32	1	29	33	7	0.6551724	2.2758621	3.229917
31	2	125	251	8	0.5920000	4.0160000	5.783419
30	3	164	657	2	0.9878049	8.0121951	3.654169
29	4	242	1083	1	1.0000000	8.9504132	3.823475
28	5	219	630	4	0.9634703	5.7534247	5.492644
27	6	232	612	11	0.4568966	5.2758621	4.255429
26	7	141	293	8	0.8865248	4.1560284	8.420352
25	8	49	122	1	1.0000000	4.9795918	3.707622
24	9	28	37	6	0.3571429	2.6428571	1.580000
23	10	64	120	7	0.8281250	3.7500000	3.925240
22	11	37	31	15	0.4864865	1.6756757	2.765432
21	12	50	102	4	0.8000000	4.0800000	2.943750
20	13	21	9	15	0.2380952	0.8571429	1.040000
19	14	17	3	14	0.2352941	0.3529412	1.250000
18	15	19	16	7	0.5263158	1.6842105	2.160000
17	16	96	275	4	0.9583333	5.7291667	3.321597
16	17	141	493	3	0.9858156	6.9929078	3.345272
15	18	107	292	6	0.9345794	5.4579439	4.228000
14	19	81	131	10	0.4938272	3.2345679	3.721250
13	20	49	71	6	0.6938776	2.8979592	3.641869
12	21	77	308	1	1.0000000	8.0000000	2.834205
11	22	98	264	4	0.9693878	5.3877551	3.405873
10	23	84	264	3	0.9761905	6.2857143	2.921178
9	24	135	466	5	0.9333333	6.9037037	3.624843
8	25	98	215	3	0.9591837	4.3877551	4.853101
7	26	69	118	2	0.9855072	3.4202899	5.508218
6	27	65	130	3	0.9692308	4.0000000	5.635173
5	28	43	118	1	1.0000000	5.4883721	2.782044
4	29	87	302	3	0.9770115	6.9425287	2.884152
3	30	149	525	2	0.9932886	7.0469799	3.792641
2	31	124	241	11	0.8548387	3.8870968	4.728195
1	32	141	351	6	0.9007092	4.9787234	5.020522

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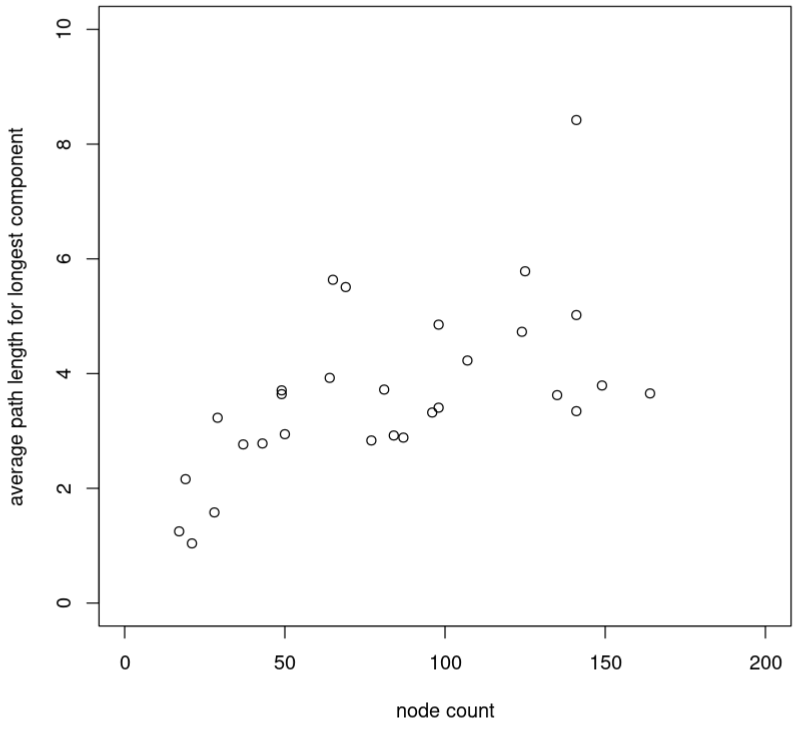
Question 3

In [4]:
```
plot(data$nodes,
     data$avg_path_length_lc,
     xlab="node count",
     ylab="average path length for longest component",
     xlim=c(0,200),
     ylim=c(0,10));
```



We might also like to see the Pearson Correation Coefficient and the level of confidence that we can have, given a default confidence level of 0.95.

In [5]:
```
result <- cor.test(data$nodes, data$avg_path_length_lc);
print("Coefficient:")
result$estimate
print("p-value:")
result$p.value
```

```
[1] "Coefficient:"
```

cor: 0.510415252889794

```
[1] "p-value:"
```

0.00283838153769246

Given the confidence level of 0.95, then we apply $\alpha = 0.05$. Since the p-value is lower than the α then this result is statistically significant. Note that this interpretation relies on their being a good sample without sampling errors.

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Regarding the networks in this analysis: each edge represents a direct contact between one vole and another. If the shortest path between two voles has more than one edge then those two voles have no direct contact.

The strong correlation between network size and average path length suggests that as a population of voles grows then each vole doesn't come into contact with every other. This could be because these animals are territorial or limit their contact with others of their species for some other survival reason.

Appendix

My code

Dumped here but not exectuted

In [ ]:
```
# my_functions.R

getAdjMatrix = function(filePath) {
    adjTable = read.table(file = filePath, header = FALSE);
    adjMatrix = as.matrix(adjTable);
    (adjMatrix);
}

# I tried for a while to display network graphs on a grid in R.
# It ended up introducing complexity. It was easier to save
# them to files and then combine them using a bash script.
# See the bash scipt makeGrid.sh
plotAllNetworks = function(networks) {
    networkVizFolder = "networkViz";
    for (i in 1:length(networks)) {
        fileName = sprintf("chart%s.png", i);
        filePath = sprintf("%s/%s",networkVizFolder, fileName);
        title = sprintf("gvole net %s", i);
        png(filePath);
        plot(networks[[i]], main=title);
        dev.off();
    }
}

collectIndices = function(uncollectedIndices, searchResult) {
    componentIndices = c();
    otherIndices = c();
    for (i in uncollectedIndices) {
        if (searchResult[[i]] == -1) {
            otherIndices = c(otherIndices, i);
        } else {
            componentIndices = c(componentIndices, i);
        }
    }
    (list(component=componentIndices, other=otherIndices));
}

# This seemed simpler, in the end, compared to using igraph.
partitionIndicesByComponent = function(network) {
    components = list();
    comp_i = 1;

    i = 1;
    searchResult = levels(network, i);
    nodeIndices = 1:length(searchResult); # These are assigned once

    indices = collectIndices(nodeIndices, searchResult);
    componentIndices = indices$component;
    components[[comp_i]] = componentIndices;
    uncollectedIndices = indices$other;

    while (length(uncollectedIndices) > 0) {
        i = uncollectedIndices[1];
        searchResult = levels(network, i);

        indices = collectIndices(uncollectedIndices, searchResult);
        componentIndices = indices$component;

        comp_i = comp_i + 1;
        components[[comp_i]] = componentIndices;
        uncollectedIndices = indices$other;
    }
    (components)
}

getLCIndices = function(components) {
    largest_i = 1;
    largestNumberOfPaths = 0;
    for (i in 1:length(components)) {
        component = components[[i]];
        if (length(component) > largestNumberOfPaths) {
            largestNumberOfPaths = length(component);
            largest_i = i;
        }
    }
    (components[[largest_i]])
}

chompMinus1 = function(vector) {
    chompedVector = c();
    for (i in 1:length(vector)) {
        if (vector[[i]] != -1) {
            chompedVector = c(chompedVector, vector[[i]]);
        }
    }
    (chompedVector)
}

getLCPathMatrix = function(LCIndices, network, n) {
    numberOfIndices = length(LCIndices);
    pathMatrix = matrix(, nrow=numberOfIndices, ncol=0);
    for (i in LCIndices) {
        pathLengths = levels(network, i);
        pathLengths = chompMinus1(pathLengths);
        pathMatrix = cbind(pathMatrix, pathLengths);
    }
    (pathMatrix)
}

getDataForNetwork = function(network, dataForAllNetworks) {
    # Let LC be largest component
    n = network.size(network);
    e = network.edgecount(network);
    indicesByComponent = partitionIndicesByComponent(network);
    numberOfComponents = length(indicesByComponent);
    LCIndices = getLCIndices(indicesByComponent);
    LCPathMatrix = getLCPathMatrix(LCIndices, network, n);
    numberOfNodesInLC = length(LCIndices);
    fractionOfNodesInLC = numberOfNodesInLC/n;
    averageDegree = mean(degree(network, gmode="graph"));
    averagePathLengthForLC = mean(LCPathMatrix);

    dataForNetwork = list(net_id=get.network.attribute(network, "net
                          nodes=n,
                          edges=e,
                          components=numberOfComponents,
                          lc_node_share=fractionOfNodesInLC,
                          avg_degree=averageDegree,
                          avg_path_length_lc=averagePathLengthForLC
    (dataForNetwork)
}

getDataForAllNetworks = function(networks) {
    dataForAllNetworks = data.frame(net_id = integer(),
                                    nodes = integer(),
                                    edges = integer(),
                                    comonents = integer(),
                                    lc_node_share = numeric(),
                                    avg_degree = numeric(),
                                    avg_path_length_lc = numeric()
                                   );

    for (i in 1:length(networks)) {
        dataForOneNetwork = getDataForNetwork(networks[[i]]);
        dataForAllNetworks = rbind(dataForOneNetwork,dataForAllNetwo
    }
    (dataForAllNetworks[order(dataForAllNetworks$net_id),])
}
```

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In [ ]:
```
# tests.R

##################################
### Test collectIndices

nodeIndices = 1:7
searchResult = c(-1,2,1,2,-1,-1,1)

result = collectIndices(nodeIndices, searchResult)

assert(as.vector(result$other) == c(1,5,6))
assert(as.vector(result$component) == c(2,3,4,7))

##################################
### Test partitionIndicesByComponent sparse network

adjMatrix = matrix(c(0,1,0,0,0,0,1,
         1,0,0,0,0,0,0,
         0,0,0,1,0,0,0,
         0,0,1,0,1,0,0,
         0,0,0,1,0,0,0,
         0,0,0,0,0,0,0,
         1,0,0,0,0,0,0),
           nrow=7,
           ncol=7)

network <- as.network.matrix(adjMatrix, matrix.type="adjacency", dire

result = partitionIndicesByComponent(network)

assert(result[[1]] == c(1,2,7))
assert(result[[2]] == c(3,4,5))
assert(result[[3]] == c(6))

##################################
### Test getLCPathLengths

components = list()
components[[1]] = c(5,4,3,2,1)
components[[2]] = c(1)
components[[3]] = c(3,2,1)

result = getLCIndices(components)

assert(result == c(5,4,3,2,1))

##################################
### Test chompMinus1

vector = c(-1,-1,1,0,2,-1,1,3)

result = chompMinus1(vector);
assert(result == c(1,0,2,1,3));

##################################
### Test getLCPathMatrix

adjMatrix = matrix(c(0,1,0,0,0,0,1,
         1,0,0,0,0,0,0,
         0,0,0,1,1,0,0,
         0,0,1,0,1,0,0,
         0,0,1,1,0,0,0,
         0,0,0,0,0,0,0,
         1,0,0,0,0,0,0),
           nrow=7,
           ncol=7)

network <- as.network.matrix(adjMatrix, matrix.type="adjacency", dire

LCIndices = c(3,4,5)

result = getLCPathMatrix(LCIndices, network, 7)

expected = matrix(c(0,1,1,
        1,0,1,
        1,1,0),
           nrow=3,
           ncol=3);

assert(result == expected);

#################################
print("Tests pass")
```

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```
In [ ]:
```