Final-project

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```
wiki2018 <- read.csv("filtered_enwiki_links_2018.csv", stringsAsFactors = FALSE)
wiki2017 <- read.csv("filtered_enwiki_links_2017.csv", stringsAsFactors = FALSE)
wiki2014 <- read.csv("filtered_enwiki_links_2014.csv", stringsAsFactors = FALSE)
```

```
if (!requireNamespace("igraph", quietly = TRUE)) install.packages("igraph")
if (!requireNamespace("ergm", quietly = TRUE)) install.packages("ergm")
if (!requireNamespace("ergm", quietly = TRUE)) install.packages("tergm")
if (!requireNamespace("network", quietly = TRUE)) install.packages("network")
if (!requireNamespace("readr", quietly = TRUE)) install.packages("readr")
library(igraph)
```

```
##
## Attaching package: 'igraph'

## The following objects are masked from 'package:stats':
##
##     decompose, spectrum

## The following object is masked from 'package:base':
##
##     union
```

```
library(ergm)
```

```
## Loading required package: network

##
## 'network' 1.18.2 (2023-12-04), part of the Statnet Project
## * 'news(package="network")' for changes since last version
## * 'citation("network")' for citation information
## * 'https://statnet.org' for help, support, and other information

##
## Attaching package: 'network'

## The following objects are masked from 'package:igraph':
##
##     %c%, %s%, add.edges, add.vertices, delete.edges, delete.vertices,
##     get.edge.attribute, get.edges, get.vertex.attribute, is.bipartite,
##     is.directed, list.edge.attributes, list.vertex.attributes,
##     set.edge.attribute, set.vertex.attribute
```

```
##
## 'ergm' 4.6.0 (2023-12-17), part of the Statnet Project
## * 'news(package="ergm")' for changes since last version
## * 'citation("ergm")' for citation information
## * 'https://statnet.org' for help, support, and other information

## 'ergm' 4 is a major update that introduces some backwards-incompatible
## changes. Please type 'news(package="ergm")' for a list of major
## changes.
```

```
library(tergm)
```

```
## Loading required package: networkDynamic
```

```
##
## 'networkDynamic' 0.11.4 (2023-12-10?), part of the Statnet Project
## * 'news(package="networkDynamic")' for changes since last version
## * 'citation("networkDynamic")' for citation information
## * 'https://statnet.org' for help, support, and other information

## Registered S3 method overwritten by 'tergm':
##   method                   from
##   simulate_formula.network ergm

##
## 'tergm' 4.2.0 (2023-05-30), part of the Statnet Project
## * 'news(package="tergm")' for changes since last version
## * 'citation("tergm")' for citation information
## * 'https://statnet.org' for help, support, and other information

##
## Attaching package: 'tergm'

## The following object is masked from 'package:ergm':
##
##     snctrl
```

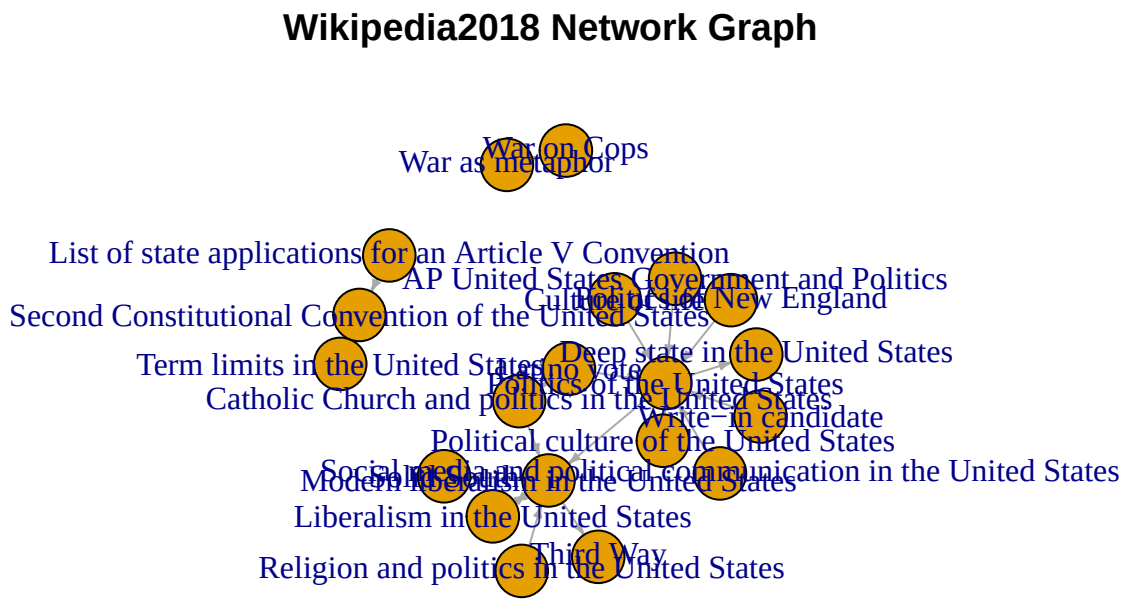
```
library(network)
library(readr)
```

```
# Ensure that vertices are created for each unique source and target, with edges between them
graph_wiki2018 <- graph_from_data_frame(d = wiki2018, directed = TRUE)
graph_wiki2017 <- graph_from_data_frame(d = wiki2017, directed = TRUE)
graph_wiki2014 <- graph_from_data_frame(d = wiki2014, directed = TRUE)

# Extract and assign labels for each vertex
V(graph_wiki2018)$name <- ifelse(is.na(match(V(graph_wiki2018)$name, wiki2018$source)),
                                 wiki2018$target_label[match(V(graph_wiki2018)$name, wiki2018$target)],
                                 wiki2018$source_label[match(V(graph_wiki2018)$name, wiki2018$source)])
V(graph_wiki2017)$name <- ifelse(is.na(match(V(graph_wiki2017)$name, wiki2017$source)),
                                 wiki2017$target_label[match(V(graph_wiki2017)$name, wiki2017$target)],
```

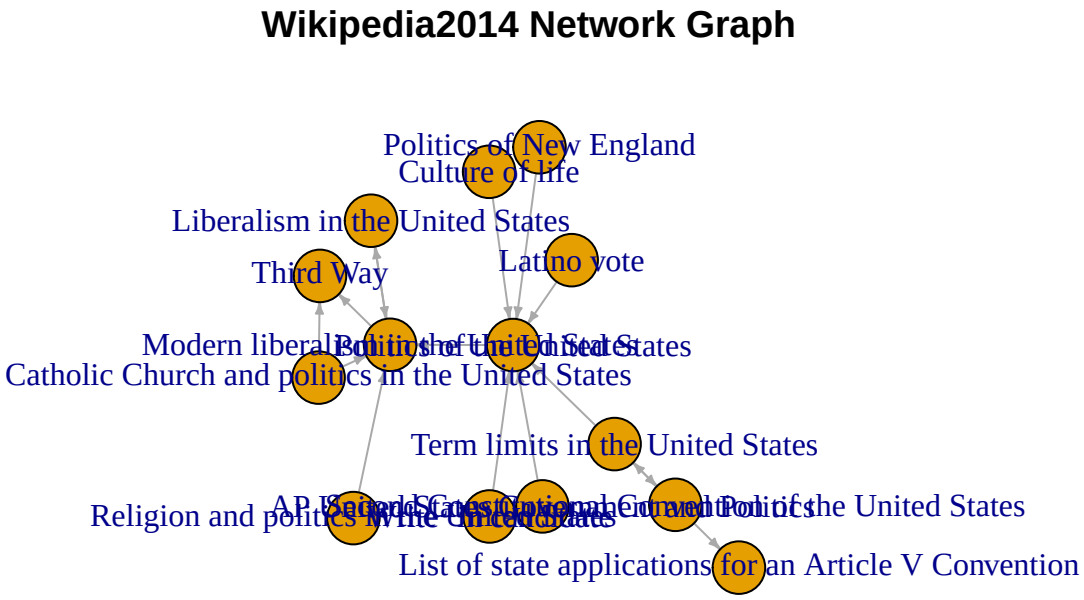
```
                                  wiki2017$source_label[match(V(graph_wiki2017)$name, wiki2017$source)])
V(graph_wiki2014)$name <- ifelse(is.na(match(V(graph_wiki2014)$name, wiki2014$source)),
                                  wiki2014$target_label[match(V(graph_wiki2014)$name, wiki2014$target)],
                                  wiki2014$source_label[match(V(graph_wiki2014)$name, wiki2014$source)])

# Now plot the graph using these labels
plot(graph_wiki2018, vertex.size=25, vertex.label.cex = 1.0, edge.arrow.size = 0.3,
     main = "Wikipedia2018 Network Graph", vertex.label = V(graph_wiki2018)$name)
```




```
plot(graph_wiki2017, vertex.size=25, vertex.label.cex = 1.0, edge.arrow.size = 0.3,
     main = "Wikipedia2017 Network Graph", vertex.label = V(graph_wiki2017)$name)
```

```
plot(graph_wiki2014, vertex.size=25, vertex.label.cex = 1.0, edge.arrow.size = 0.3,
     main = "Wikipedia2014 Network Graph", vertex.label = V(graph_wiki2014)$name)
```




```
# Apply the algorithms to the directed graph
community_detection_infomap <- cluster_infomap(graph_wiki2018)
community_detection_edge_betweenness <- cluster_edge_betweenness(graph_wiki2018)

# Calculate the modularity scores
modularity_score_infomap <- modularity(community_detection_infomap)
modularity_edge_betweenness <- modularity(community_detection_edge_betweenness)
print(paste("Modularity Score (Infomap) 2018:", modularity_score_infomap))
```

```
## [1] "Modularity Score (Infomap) 2018: 0.586776859504132"
```

```
print(paste("Modularity Score (Edge Betweenness) 2018:", modularity_edge_betweenness))
```

```
## [1] "Modularity Score (Edge Betweenness) 2018: 0.502066115702479"
```

```
# Check the numbers of communities detected
num_communities_infomap <- length(sizes(community_detection_infomap))
num_communities_eb <- length(sizes(community_detection_edge_betweenness))
print(paste("Number of communities detected with Infomap 2018:", num_communities_infomap))
```

```
## [1] "Number of communities detected with Infomap 2018: 5"
```

```
print(paste("Number of communities detected with Edge Betweenness 2018:", num_communities_eb))
```

```
## [1] "Number of communities detected with Edge Betweenness 2018: 5"
```

```r
# community membership list
membership_vector <- membership(community_detection_infomap)
print(membership_vector)
```

```
##                                 Politics of the United States
##                                                             1
##                                              Write-in candidate
##                                                             1
##                                                 Culture of life
##                                                             1
##             Catholic Church and politics in the United States
##                                                             2
##                       AP United States Government and Politics
##                                                             1
##                         Modern liberalism in the United States
##                                                             3
##                                Term limits in the United States
##                                                             4
##                                                 War as metaphor
##                                                             5
##                                Liberalism in the United States
##                                                             3
##                     Religion and politics in the United States
##                                                             3
##        List of state applications for an Article V Convention
##                                                             4
##         Second Constitutional Convention of the United States
##                                                             4
##                                                   Latino vote
##                                                             2
##                                        Politics of New England
##                                                             1
## Social media and political communication in the United States
##                                                             1
##                         Political culture of the United States
##                                                             1
##                                Deep state in the United States
##                                                             1
##                                                   Solid South
##                                                             3
##                                                     Third Way
##                                                             3
##                                                   War on Cops
##                                                             5
```

```r
# Apply the algorithms to the directed graph
community_detection_infomap <- cluster_infomap(graph_wiki2017)
community_detection_edge_betweenness <- cluster_edge_betweenness(graph_wiki2017)

# Calculate the modularity scores
modularity_score_infomap <- modularity(community_detection_infomap)
modularity_edge_betweenness <- modularity(community_detection_edge_betweenness)
print(paste("Modularity Score (Infomap) 2017:", modularity_score_infomap))
```

```
## [1] "Modularity Score (Infomap) 2017: 0.551652892561983"
```

```
print(paste("Modularity Score (Edge Betweenness) 2017:", modularity_edge_betweenness))
```

```
## [1] "Modularity Score (Edge Betweenness) 2017: 0.421487603305785"
```

```
# Check the numbers of communities detected
num_communities_infomap <- length(sizes(community_detection_infomap))
num_communities_eb <- length(sizes(community_detection_edge_betweenness))
print(paste("Number of communities detected with Infomap 2017:", num_communities_infomap))
```

```
## [1] "Number of communities detected with Infomap 2017: 5"
```

```
print(paste("Number of communities detected with Edge Betweenness 2017:", num_communities_eb))
```

```
## [1] "Number of communities detected with Edge Betweenness 2017: 6"
```

```
membership_vector <- membership(community_detection_infomap)
print(membership_vector)
```

```
##                                 Politics of the United States
##                                                             1
##                                            Write-in candidate
##                                                             1
##                                               Culture of life
##                                                             1
##             Catholic Church and politics in the United States
##                                                             2
##                       AP United States Government and Politics
##                                                             1
##                         Modern liberalism in the United States
##                                                             3
##                                Term limits in the United States
##                                                             4
##                                               War as metaphor
##                                                             5
##                                Liberalism in the United States
##                                                             3
##                     Religion and politics in the United States
##                                                             3
##        List of state applications for an Article V Convention
##                                                             4
##         Second Constitutional Convention of the United States
##                                                             4
##                                                  Latino vote
##                                                             2
##                                       Politics of New England
##                                                             1
## Social media and political communication in the United States
##                                                             1
##                         Political culture of the United States
```

```
##                                                     1
##                              Deep state in the United States
##                                                     1
##                                                Third Way
##                                                     3
##                                               War on Cops
##                                                     5
```

```
# Apply the algorithms to the directed graph
community_detection_infomap <- cluster_infomap(graph_wiki2014)
community_detection_edge_betweenness <- cluster_edge_betweenness(graph_wiki2014)

# Calculate the modularity scores
modularity_score_infomap <- modularity(community_detection_infomap)
modularity_edge_betweenness <- modularity(community_detection_edge_betweenness)
print(paste("Modularity Score (Infomap) 2014:", modularity_score_infomap))
```

```
## [1] "Modularity Score (Infomap) 2014: 0"
```

```
print(paste("Modularity Score (Edge Betweenness) 2014:", modularity_edge_betweenness))
```

```
## [1] "Modularity Score (Edge Betweenness) 2014: 0.5234375"
```

```
# Check the numbers of communities detected
num_communities_infomap <- length(sizes(community_detection_infomap))
num_communities_eb <- length(sizes(community_detection_edge_betweenness))
print(paste("Number of communities detected with Infomap 2014:", num_communities_infomap))
```

```
## [1] "Number of communities detected with Infomap 2014: 1"
```

```
print(paste("Number of communities detected with Edge Betweenness 2014:", num_communities_eb))
```

```
## [1] "Number of communities detected with Edge Betweenness 2014: 3"
```

```
membership_vector <- membership(community_detection_infomap)
print(membership_vector)
```

```
##                          Politics of the United States
##                                                     1
##                                      Write-in candidate
##                                                     1
##                                         Culture of life
##                                                     1
##      Catholic Church and politics in the United States
##                                                     1
##                AP United States Government and Politics
##                                                     1
##                  Modern liberalism in the United States
##                                                     1
##                        Term limits in the United States
```

```
##                                                     1
##                        Liberalism in the United States
##                                                     1
##             Religion and politics in the United States
##                                                     1
##  Second Constitutional Convention of the United States
##                                                     1
##                                              Latino vote
##                                                     1
##                                 Politics of New England
##                                                     1
##                                               Third Way
##                                                     1
## List of state applications for an Article V Convention
##                                                     1
```

```
# Calculate Observed Centrality Measures
in_degree_centrality <- degree(graph_wiki2018, mode = "in")
out_degree_centrality <- degree(graph_wiki2018, mode = "out")

# Print the in-degree centrality
print("In-degree Centrality in 2018:")
```

```
## [1] "In-degree Centrality in 2018:"
```

```
print(in_degree_centrality)
```

```
##                                 Politics of the United States
##                                                             7
##                                              Write-in candidate
##                                                             0
##                                                 Culture of life
##                                                             0
##             Catholic Church and politics in the United States
##                                                             1
##                       AP United States Government and Politics
##                                                             0
##                         Modern liberalism in the United States
##                                                             4
##                                Term limits in the United States
##                                                             1
##                                                War as metaphor
##                                                             0
##                                Liberalism in the United States
##                                                             1
##                     Religion and politics in the United States
##                                                             0
##        List of state applications for an Article V Convention
##                                                             0
##         Second Constitutional Convention of the United States
##                                                             2
##                                                    Latino vote
##                                                             1
```

```
##                                     Politics of New England
##                                                           0
## Social media and political communication in the United States
##                                                           0
##                         Political culture of the United States
##                                                           1
##                                Deep state in the United States
##                                                           1
##                                                 Solid South
##                                                           1
##                                                   Third Way
##                                                           1
##                                                 War on Cops
##                                                           1
```

```
# Print the out-degree centrality
print("Out-degree Centrality in 2018:")
```

```
## [1] "Out-degree Centrality in 2018:"
```

```
print(out_degree_centrality)
```

```
##                                  Politics of the United States
##                                                              3
##                                              Write-in candidate
##                                                              1
##                                                 Culture of life
##                                                              1
##             Catholic Church and politics in the United States
##                                                              2
##                       AP United States Government and Politics
##                                                              1
##                         Modern liberalism in the United States
##                                                              3
##                                Term limits in the United States
##                                                              1
##                                                 War as metaphor
##                                                              1
##                                Liberalism in the United States
##                                                              1
##                     Religion and politics in the United States
##                                                              1
##        List of state applications for an Article V Convention
##                                                              1
##         Second Constitutional Convention of the United States
##                                                              1
##                                                 Latino vote
##                                                              2
##                                     Politics of New England
##                                                              1
## Social media and political communication in the United States
##                                                              1
##                         Political culture of the United States
```

```
##                                                     1
##                               Deep state in the United States
##                                                     0
##                                                Solid South
##                                                     0
##                                                  Third Way
##                                                     0
##                                                War on Cops
##                                                     0
```

```
# Calculate Observed Centrality Measures
in_degree_centrality <- degree(graph_wiki2017, mode = "in")
out_degree_centrality <- degree(graph_wiki2017, mode = "out")

# Print the in-degree centrality
print("In-degree Centrality in 2017:")
```

```
## [1] "In-degree Centrality in 2017:"
```

```
print(in_degree_centrality)
```

```
##                                 Politics of the United States
##                                                     7
##                                           Write-in candidate
##                                                     0
##                                              Culture of life
##                                                     0
##             Catholic Church and politics in the United States
##                                                     1
##                       AP United States Government and Politics
##                                                     0
##                         Modern liberalism in the United States
##                                                     4
##                               Term limits in the United States
##                                                     1
##                                              War as metaphor
##                                                     0
##                               Liberalism in the United States
##                                                     1
##                     Religion and politics in the United States
##                                                     0
##        List of state applications for an Article V Convention
##                                                     0
##         Second Constitutional Convention of the United States
##                                                     2
##                                                Latino vote
##                                                     1
##                                     Politics of New England
##                                                     0
## Social media and political communication in the United States
##                                                     0
##                         Political culture of the United States
##                                                     1
```

```
##                                Deep state in the United States
##                                                              1
##                                                      Third Way
##                                                              2
##                                                    War on Cops
##                                                              1
```

```
# Print the out-degree centrality
print("Out-degree Centrality in 2017:")
```

```
## [1] "Out-degree Centrality in 2017:"
```

```
print(out_degree_centrality)
```

```
##                                  Politics of the United States
##                                                              3
##                                               Write-in candidate
##                                                              1
##                                                  Culture of life
##                                                              1
##             Catholic Church and politics in the United States
##                                                              3
##                       AP United States Government and Politics
##                                                              1
##                         Modern liberalism in the United States
##                                                              2
##                                Term limits in the United States
##                                                              1
##                                                  War as metaphor
##                                                              1
##                                Liberalism in the United States
##                                                              1
##                     Religion and politics in the United States
##                                                              1
##        List of state applications for an Article V Convention
##                                                              1
##         Second Constitutional Convention of the United States
##                                                              1
##                                                    Latino vote
##                                                              2
##                                         Politics of New England
##                                                              1
## Social media and political communication in the United States
##                                                              1
##                         Political culture of the United States
##                                                              1
##                                Deep state in the United States
##                                                              0
##                                                      Third Way
##                                                              0
##                                                    War on Cops
##                                                              0
```

```r
# Calculate Observed Centrality Measures
in_degree_centrality <- degree(graph_wiki2014, mode = "in")
out_degree_centrality <- degree(graph_wiki2014, mode = "out")

# Print the in-degree centrality
print("In-degree Centrality in 2014:")
```

```
## [1] "In-degree Centrality in 2014:"
```

```r
print(in_degree_centrality)
```

```
##                           Politics of the United States
##                                                        6
##                                       Write-in candidate
##                                                        0
##                                          Culture of life
##                                                        0
##      Catholic Church and politics in the United States
##                                                        0
##                AP United States Government and Politics
##                                                        0
##                  Modern liberalism in the United States
##                                                        4
##                        Term limits in the United States
##                                                        1
##                         Liberalism in the United States
##                                                        1
##              Religion and politics in the United States
##                                                        0
##  Second Constitutional Convention of the United States
##                                                        1
##                                               Latino vote
##                                                        0
##                                  Politics of New England
##                                                        0
##                                                Third Way
##                                                        2
## List of state applications for an Article V Convention
##                                                        1
```

```r
# Print the out-degree centrality
print("Out-degree Centrality in 2014:")
```

```
## [1] "Out-degree Centrality in 2014:"
```

```r
print(out_degree_centrality)
```

```
##                           Politics of the United States
##                                                        1
##                                       Write-in candidate
##                                                        1
```

```
##                                       Culture of life
##                                                     1
##      Catholic Church and politics in the United States
##                                                     2
##               AP United States Government and Politics
##                                                     1
##                 Modern liberalism in the United States
##                                                     2
##                       Term limits in the United States
##                                                     2
##                        Liberalism in the United States
##                                                     1
##             Religion and politics in the United States
##                                                     1
##  Second Constitutional Convention of the United States
##                                                     2
##                                           Latino vote
##                                                     1
##                                Politics of New England
##                                                     1
##                                             Third Way
##                                                     0
## List of state applications for an Article V Convention
##                                                     0
```

```
edge_list2018 <- read.csv("filtered_enwiki_links_2018.csv", stringsAsFactors = FALSE)
net_wiki2018 <- network(edge_list2018[, c("source", "target")], directed = TRUE)
set.vertex.attribute(net_wiki2018, "label", edge_list2018$source_label[match(network.vertex.names(net_wi
ergm_2018 <- ergm(net_wiki2018 ~ edges + mutual + transitiveties + gwesp(0.2, fixed = TRUE))
```

```
## Observed statistic(s) transitiveties are at their smallest attainable values. Their coefficients will

## Starting maximum pseudolikelihood estimation (MPLE):

## Obtaining the responsible dyads.

## Evaluating the predictor and response matrix.

## Maximizing the pseudolikelihood.

## Finished MPLE.

## Starting Monte Carlo maximum likelihood estimation (MCMLE):

## Iteration 1 of at most 60:

## Model statistics 'gwesp.OTP.fixed.0.2' are not varying. This may indicate that the observed data occu

## Warning: 'glpk' selected as the solver, but package 'Rglpk' is not available;
## falling back to 'lpSolveAPI'. This should be fine unless the sample size and/or
## the number of parameters is very big.
```

```
## Optimizing with step length 1.0000.

## The log-likelihood improved by 0.1315.

## Estimating equations are not within tolerance region.

## Iteration 2 of at most 60:

## Model statistics 'gwesp.OTP.fixed.0.2' are not varying. This may indicate that the observed data occu

## Optimizing with step length 1.0000.

## The log-likelihood improved by 0.0005.

## Convergence test p-value: < 0.0001. Converged with 99% confidence.
## Finished MCMLE.
## Evaluating log-likelihood at the estimate. Fitting the dyad-independent submodel...
## Bridging between the dyad-independent submodel and the full model...
## Setting up bridge sampling...
## Using 16 bridges: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 .
## Bridging finished.
##
## This model was fit using MCMC.  To examine model diagnostics and check
## for degeneracy, use the mcmc.diagnostics() function.
```

```
summary(ergm_2018)
```

```
## Call:
## ergm(formula = net_wiki2018 ~ edges + mutual + transitiveties +
##     gwesp(0.2, fixed = TRUE))
##
## Monte Carlo Maximum Likelihood Results:
##
##                     Estimate Std. Error MCMC % z value Pr(>|z|)
## edges                -3.0499     0.2859      0 -10.670  < 1e-04 ***
## mutual                2.5211     0.7424      0   3.396 0.000684 ***
## transitiveties          -Inf     0.0000      0    -Inf  < 1e-04 ***
## gwesp.OTP.fixed.0.2   0.0000         NA     NA      NA       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
##  Warning: The following terms have infinite coefficient estimates:
##   transitiveties
```

```
edge_list2017 <- read.csv("filtered_enwiki_links_2017.csv", stringsAsFactors = FALSE)
net_wiki2017 <- network(edge_list2017[, c("source", "target")], directed = TRUE)
set.vertex.attribute(net_wiki2017, "label", edge_list2017$source_label[match(network.vertex.names(net_wi
ergm_2017 <- ergm(net_wiki2017 ~ edges + mutual + transitiveties)
```

```
## Starting maximum pseudolikelihood estimation (MPLE):
```

```
## Obtaining the responsible dyads.

## Evaluating the predictor and response matrix.

## Maximizing the pseudolikelihood.

## Finished MPLE.

## Starting Monte Carlo maximum likelihood estimation (MCMLE):

## Iteration 1 of at most 60:

## Optimizing with step length 1.0000.

## The log-likelihood improved by 0.1462.

## Estimating equations are not within tolerance region.

## Iteration 2 of at most 60:

## Optimizing with step length 1.0000.

## The log-likelihood improved by 0.0457.

## Convergence test p-value: 0.0010. Converged with 99% confidence.
## Finished MCMLE.
## Evaluating log-likelihood at the estimate. Fitting the dyad-independent submodel...
## Bridging between the dyad-independent submodel and the full model...
## Setting up bridge sampling...
## Using 16 bridges: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 .
## Bridging finished.
##
## This model was fit using MCMC.  To examine model diagnostics and check
## for degeneracy, use the mcmc.diagnostics() function.
```

```
summary(ergm_2017)
```

```
## Call:
## ergm(formula = net_wiki2017 ~ edges + mutual + transitiveties)
##
## Monte Carlo Maximum Likelihood Results:
##
##                Estimate Std. Error MCMC % z value Pr(>|z|)
## edges           -3.0480     0.2877      0 -10.594  < 1e-04 ***
## mutual           2.5215     0.7024      0   3.590 0.000331 ***
## transitiveties  -0.2398     0.6503      0  -0.369 0.712324
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##      Null Deviance: 474.1  on 342  degrees of freedom
##  Residual Deviance: 153.7  on 339  degrees of freedom
##
## AIC: 159.7  BIC: 171.2  (Smaller is better. MC Std. Err. = 0.2482)
```

```r
edge_list2014 <- read.csv("filtered_enwiki_links_2014.csv", stringsAsFactors = FALSE)
net_wiki2014 <- network(edge_list2014[, c("source", "target")], directed = TRUE)
set.vertex.attribute(net_wiki2014, "label", edge_list2014$source_label[match(network.vertex.names(net_wi
ergm_2014 <- ergm(net_wiki2014 ~ edges + mutual + transitiveties + gwesp(0.2, fixed = TRUE))
```

```
## Starting maximum pseudolikelihood estimation (MPLE):

## Obtaining the responsible dyads.

## Evaluating the predictor and response matrix.

## Maximizing the pseudolikelihood.

## Finished MPLE.

## Warning: Model statistics 'gwesp.OTP.fixed.0.2' are linear combinations of some
## set of preceding statistics at the current stage of the estimation. This may
## indicate that the model is nonidentifiable.

## Starting Monte Carlo maximum likelihood estimation (MCMLE):

## Iteration 1 of at most 60:

## Optimizing with step length 0.9524.

## The log-likelihood improved by 0.2123.

## Estimating equations are not within tolerance region.

## Iteration 2 of at most 60:

## Optimizing with step length 0.9524.

## The log-likelihood improved by 0.1831.

## Estimating equations are not within tolerance region.

## Iteration 3 of at most 60:

## Warning: Model statistics 'gwesp.OTP.fixed.0.2' are linear combinations of some
## set of preceding statistics at the current stage of the estimation. This may
## indicate that the model is nonidentifiable.

## Optimizing with step length 1.0000.

## Warning: Approximate Hessian matrix is singular. Standard errors due to MCMC
## approximation of the likelihood cannot be evaluated. This is likely due to
## insufficient MCMC sample size or highly correlated model terms.
```

```
## The log-likelihood improved by 0.0240.

## Unable to test for convergence; increasing sample size.

## Iteration 4 of at most 60:

## Optimizing with step length 0.9524.

## The log-likelihood improved by 0.0277.

## Convergence test p-value: < 0.0001. Converged with 99% confidence.
## Finished MCMLE.
## Evaluating log-likelihood at the estimate. Fitting the dyad-independent submodel...
## Bridging between the dyad-independent submodel and the full model...
## Setting up bridge sampling...
## Using 16 bridges: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 .
## Bridging finished.
##
## This model was fit using MCMC.  To examine model diagnostics and check
## for degeneracy, use the mcmc.diagnostics() function.
```

```
summary(ergm_2014)
```

```
## Call:
## ergm(formula = net_wiki2014 ~ edges + mutual + transitiveties +
##     gwesp(0.2, fixed = TRUE))
##
## Monte Carlo Maximum Likelihood Results:
##
##                     Estimate Std. Error MCMC % z value Pr(>|z|)
## edges                -2.5549     0.3663      0  -6.975   <1e-04 ***
## mutual                1.5692     0.9596      0   1.635    0.102
## transitiveties       20.5308   118.6549      0   0.173    0.863
## gwesp.OTP.fixed.0.2 -20.6303   118.6157      0  -0.174    0.862
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##      Null Deviance: 252.3  on 182  degrees of freedom
##  Residual Deviance: 106.3  on 178  degrees of freedom
##
## AIC: 114.3  BIC: 127.1  (Smaller is better. MC Std. Err. = 0.1396)
```