

# Package ‘ERPM’

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**Type** Package

**Title** Exponential Random Partition Models

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**Description** Simulates and estimates the Exponential Random Partition Model presented in the paper Hoffman, Block, and Snijders (2023) <[doi:10.1177/00811750221145166](https://doi.org/10.1177/00811750221145166)>. It can also be used to estimate longitudinal partitions, following the model proposed in Hoffman and Chabot (2023) <[doi:10.1016/j.socnet.2023.04.002](https://doi.org/10.1016/j.socnet.2023.04.002)>. The model is an exponential family distribution on the space of partitions (sets of non-overlapping groups) and is called in reference to the Exponential Random Graph Models (ERGM) for networks.

**License** GPL (>= 3)

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'functions\_Metropolis.R' 'functions\_burninthing.R'  
'functions\_change\_statistics.R' 'functions\_estimate.R'  
'functions\_exactcalculations.R'  
'functions\_exchange\_algorithm.R' 'functions\_loglikelihood.R'  
'functions\_output.R' 'functions\_phase1.R' 'functions\_phase2.R'  
'functions\_phase3.R' 'functions\_statistics.R'  
'functions\_visualisation.R' 'outcomeObjects.R'

**URL** <https://github.com/stocnet/ERPM>

**BugReports** <https://github.com/stocnet/ERPM/issues>

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Bell_constraints	<i>Function to calculate the number of partitions with groups of sizes between smin and smax</i>
------------------	--

---

## Description

Function to calculate the number of partitions with groups of sizes between smin and smax

## Usage

```
Bell_constraints(n, smin, smax)
```

## Arguments

n	number of nodes
smin	minimum group size possible in the partition
smax	minimum group size possible in the partition

## Value

a numeric

## Examples

```
n <- 6
size_min <- 2
size_max <- 4
Bell_constraints(n,size_min,size_max)
```

---

calculate\_denominator\_Dirichlet\_restricted  
*Calculate Dirichlet denominator*

---

**Description**

Recursive function to calculate the denominator for the model with a single statistic for the number of groups and a given parameter value. The set of possible partitions can be restricted to partitions with groups of a certain size.

**Usage**

```
calculate_denominator_Dirichlet_restricted(n, smin, smax, alpha, results)
```

**Arguments**

n	number of nodes
smin	minimum size for a group
smax	maximum size for a group
alpha	parameter value
results	a list

**Value**

a numeric

---

calculate\_proba\_Dirichlet\_restricted  
*Calculate Dirichlet probability*

---

**Description**

Calculate the probability of observing a partition with a given number of groups for a model with a single statistic for the number of groups and a given parameter value. The set of possible partitions can be restricted to partitions with groups of a certain size.

**Usage**

```
calculate_proba_Dirichlet_restricted(alpha, stat, n, smin, smax)
```

**Arguments**

alpha	parameter value
stat	observed stat (number of groups)
n	number of nodes
smin	minimum size for a group
smax	maximum size for a group

**Value**

a numeric

---

check_sizes	<i>Function to determine whether a partition contains the allowed group sizes</i>
-------------	---

---

**Description**

Function to determine whether a partition contains the allowed group sizes

**Usage**

```
check_sizes(partition, sizes.allowed, numgroups.allowed)
```

**Arguments**

partition	observed partition
sizes.allowed	vector containing possible group sizes in the partition
numgroups.allowed	vector containing possible number of groups in the partition

**Value**

boolean

---

computeStatistics      *Compute Statistics*

---

**Description**

Function that computes the statistic vector for a given partition and a given model

**Usage**

```
computeStatistics(partition, nodes, effects, objects)
```

**Arguments**

partition	vector, A partition
nodes	data frame, Node set
effects	list with a vector "names", and a vector "objects", Effects/sufficient statistics
objects	list with a vector "name", and a vector "object", Objects used for statistics calculation

**Value**

the statistics

---

computeStatistics\_multiple  
*Compute Statistics multiple*

---

**Description**

Function that computes the statistic vector for given (multiple) partitions and a given model

**Usage**

```
computeStatistics_multiple(  
  partitions,  
  presence.tables,  
  nodes,  
  effects,  
  objects,  
  single.obs = NULL  
)
```

**Arguments**

partitions	Observed partitions
presence.tables	to indicate which nodes were present when
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
single.obs	equal NULL by default

**Value**

A list

---

compute\_averagesize    *Compute the average size of a random partition*

---

**Description**

Recursive function to compute the average size of a random partition for a given number of nodes

**Usage**

```
compute_averagesize(num.nodes)
```

**Arguments**

num.nodes	number of nodes
-----------	-----------------

**Value**

a numeric

**Examples**

```
n <- 6  
compute_averagesize(n)
```

compute\_numgroups\_denominator

*Compute denominator for model with number of groups*

---

### Description

Recursive function to compute the value of the denominator for the model with a single statistic which is the number of groups

### Usage

```
compute_numgroups_denominator(num.nodes, alpha)
```

### Arguments

num.nodes	number of nodes
alpha	parameter value

### Value

a numeric

---

correlation\_between *Between groups correlation*

---

### Description

This function computes the correlation between the group averages of the two attributes.

### Usage

```
correlation_between(partition, attribute1, attribute2)
```

### Arguments

partition	A partition (vector)
attribute1	A vector containing the values of the first attribute
attribute2	A vector containing the values of the second attribute

### Value

A number corresponding to the correlation coefficient



**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
at2 <- c(3,5,20,2,1,0,0,9,0)
correlation_between(p,at,at2)
```

---

correlation\_within      *Within groups correlation*

---

**Description**

This function computes the correlation between the two attributes for individuals in the same group.

**Usage**

```
correlation_within(partition, attribute1, attribute2, group)
```

**Arguments**

partition	A partition (vector)
attribute1	A vector containing the values of the first attribute
attribute2	A vector containing the values of the second attribute
group	A number indicating the selected group

**Value**

A number corresponding to the correlation coefficient

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
at2 <- c(3,5,20,2,1,0,0,9,0)
correlation_within(p,at,at2,4)
```

---

correlation\_with\_size *Correlation with size*

---

### Description

This function computes the correlation between an attribute and the size of the groups.

### Usage

```
correlation_with_size(partition, attribute, categorical)
```

### Arguments

partition	A partition (vector)
attribute	A vector containing the values of the attribute
categorical	A Boolean (True or False) indicating if the attribute is categorical

### Value

A number corresponding to the correlation coefficient if the attribute is numerical or the correlation ratio if the attribute is categorical.

### Examples

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
correlation_with_size(p,at,categorical=FALSE)
```

---

count_classes	<i>Function to count the number of partitions with a certain group size structure, for all possible group size structure. Function to use after calling the "find_all_partitions" function.</i>
---------------	---

---

### Description

Function to count the number of partitions with a certain group size structure, for all possible group size structure. Function to use after calling the "find\_all\_partitions" function.

### Usage

```
count_classes(allpartitions)
```

### Arguments

allpartitions	matrix containing all possible partitions for a nodeset
---------------	---

**Value**

integer(number of partitions with different group structures)

**Examples**

```
#find partitions first
n <- 6
all_partitions <- find_all_partitions(n)
# count classes
counts_partition_classes <- count_classes(all_partitions)
```

---

CUP

---

*CUP*


---

**Description**

This function tests a partition statistic against a "conditional uniform partition null hypothesis: It compares a statistic computed on an observed partition and the same statistic computed on a set of permuted partition (partitions with the same group structure as the observed partition, with nodes being permuted).

**Usage**

```
CUP(observation, fun, permutations = NULL, num.permutations = 1000)
```

**Arguments**

**observation** A vector giving the observed partition

**fun** A function used to compute a given partition statistic to be computed

**permutations** A matrix, whose lines contain partitions which are permutations of the observed partition. This argument is `NULL` by default (in that case, the permutations are created automatically).

**num.permutations** An integer indicating the number of permutations to generate, if they are not already given. 1000 permutations are generated by default.

**Details**

This test is similar to Conditional Uniform Graph tests in networks (we translate this into Conditional Uniform Partition tests).

**Value**

The value of the statistic calculated for the observed partition, the mean value of the statistic among permuted partitions, the standard deviation of the statistic among permuted partitions, the proportion of permutation below the observed statistic, the proportion of permutation above the observed statistic, the lower boundary of the 95% CI, the upper boundary of the 95% CI

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(0,1,1,1,1,0,0,0,0)
CUP(p, fun=function(x){same_pairs(x, at, 'avg_pergrout')})
```

---

```
draw_Metropolis_multiple
```

*Draw Metropolis multiple*

---

**Description**

Function to sample the model with a Markov chain (single partition procedure).

**Usage**

```
draw_Metropolis_multiple(
  theta,
  first.partitions,
  presence.tables,
  nodes,
  effects,
  objects,
  burnin,
  thinning,
  num.steps,
  neighborhood = c(0.7, 0.3, 0),
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  return.all.partitions = FALSE,
  verbose = FALSE
)
```

**Arguments**

theta	model parameters
first.partitions	starting partition for the Markov chain
presence.tables	matrix indicating which actors were present for each observations (mandatory)
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")

**burnin** integer for the number of burn-in steps before sampling  
**thining** integer for the number of thinning steps between sampling  
**num.steps** number of samples  
**neighborhood** = c(0.7,0.3,0), way of choosing partitions: probability vector (2 actors swap, merge/division, single actor move, single pair move, 2 pairs swap, 2 groups reshuffle)  
**numgroups.allowed**  
= NULL, # vector containing the number of groups allowed in the partition (now, it only works with vectors like num\_min:num\_max)  
**numgroups.simulated**  
= NULL, # vector containing the number of groups simulated  
**sizes.allowed** = NULL, vector of group sizes allowed in sampling (now, it only works for vectors like size\_min:size\_max)  
**sizes.simulated**  
= NULL, vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size\_min:size\_max)  
**return.all.partitions**  
= FALSE, option to return the sampled partitions on top of their statistics (for GOF)  
**verbose** logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

## Value

A list

## Examples

```

# define an arbitrary set of n = 6 nodes with attributes, and an arbitrary covariate matrix
n <- 6
nodes <- data.frame(label = c("A", "B", "C", "D", "E", "F"),
                    gender = c(1,1,2,1,2,2),
                    age = c(20,22,25,30,30,31))
friendship <- matrix(c(0, 1, 1, 1, 0, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 0, 0,
                      0, 1, 1, 0, 0, 1,
                      0, 0, 0, 0, 1, 0), 6, 6, TRUE)

# specify whether nodes are present at different points of time
presence.tables <- matrix(c(1, 1, 1, 1, 1, 1,
                           0, 1, 1, 1, 1, 1,
                           1, 0, 1, 1, 1, 1), 6, 3)

# choose effects to be included in the estimated model
effects_multiple <- list(names = c("num_groups", "same", "diff", "tie", "inertia_1"),
                        objects = c("partitions", "gender", "age", "friendship", "partitions"),

```

```

      objects2 = c("", "", "", "", ""))
objects_multiple <- list()
objects_multiple[[1]] <- list(name = "friendship", object = friendship)

# set parameter values for each of these effects
parameters <- c(-0.2,0.2,-0.1,0.5,1)

# set a starting point for the simulation
first.partitions <- matrix(c(1, 1, 2, 2, 2, 3,
                             NA, 1, 1, 2, 2, 2,
                             1, NA, 2, 3, 3, 1), 6, 3)

# generate the simulated sample
nsteps <- 50
sample <- draw_Metropolis_multiple(theta = parameters,
                                   first.partitions = first.partitions,
                                   nodes = nodes,
                                   presence.tables = presence.tables,
                                   effects = effects_multiple,
                                   objects = objects_multiple,
                                   burnin = 100,
                                   thinning = 100,
                                   num.steps = nsteps,
                                   neighborhood = c(0,1,0),
                                   numgroups.allowed = 1:n,
                                   numgroups.simulated = 1:n,
                                   sizes.allowed = 1:n,
                                   sizes.simulated = 1:n,
                                   return.all.partitions = TRUE)

```

---

draw\_Metropolis\_single

*Draw Metropolis single*

---

### Description

Function to sample the model with a Markov chain (single partition procedure).

### Usage

```

draw_Metropolis_single(
  theta,
  first.partition,
  nodes,
  effects,
  objects,

```

```

    burnin,
    thinning,
    num.steps,
    neighborhood = c(0.7, 0.3, 0),
    numgroups.allowed = NULL,
    numgroups.simulated = NULL,
    sizes.allowed = NULL,
    sizes.simulated = NULL,
    return.all.partitions = FALSE
  )

```

### Arguments

theta	model parameters
first.partition	starting partition for the Markov chain
nodes	nodeset (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
burnin	integer for the number of burn-in steps before sampling
thinning	integer for the number of thinning steps between sampling
num.steps	number of samples
neighborhood	= c(0.7,0.3,0), way of choosing partitions: probability vector (2 actors swap, merge/division, single actor move, single pair move, 2 pairs swap, 2 groups reshuffle)
numgroups.allowed	= NULL, # vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	= NULL, # vector containing the number of groups simulated
sizes.allowed	= NULL, vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	= NULL, vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
return.all.partitions	= FALSE option to return the sampled partitions on top of their statistics (for GOF)

### Value

A list

**Examples**

```

# define an arbitrary set of n = 6 nodes with attributes, and an arbitrary covariate matrix
n <- 6
nodes <- data.frame(label = c("A", "B", "C", "D", "E", "F"),
                    gender = c(1, 1, 2, 1, 2, 2),
                    age = c(20, 22, 25, 30, 30, 31))
friendship <- matrix(c(0, 1, 1, 1, 0, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 0, 0,
                      0, 1, 1, 0, 0, 1,
                      0, 0, 0, 0, 1, 0), 6, 6, TRUE)

# choose the effects to be included (see manual for all effect names)
effects <- list(names = c("num_groups", "same", "diff", "tie"),
               objects = c("partition", "gender", "age", "friendship"))
objects <- list()
objects[[1]] <- list(name = "friendship", object = friendship)

# set parameter values for each of these effects
parameters <- c(-0.2, 0.2, -0.1, 0.5)

# generate simulated sample, by setting the desired additional parameters for the
# Metropolis sampler and choosing a starting point for the chain (first.partition)
nsteps <- 100
sample <- draw_Metropolis_single(theta = parameters,
                               first.partition = c(1, 1, 2, 2, 3, 3),
                               nodes = nodes,
                               effects = effects,
                               objects = objects,
                               burnin = 100,
                               thinning = 10,
                               num.steps = nsteps,
                               neighborhood = c(0, 1, 0),
                               numgroups.allowed = 1:n,
                               numgroups.simulated = 1:n,
                               sizes.allowed = 1:n,
                               sizes.simulated = 1:n,
                               return.all.partitions = TRUE)

# or: simulate an estimated model
partition <- c(1, 1, 2, 2, 2, 3) # the partition already defined for the (previous) estimation
nsimulations <- 1000
simulations <- draw_Metropolis_single(theta = estimation$results$est,
                                     first.partition = partition,
                                     nodes = nodes,
                                     effects = effects,
                                     objects = objects,
                                     burnin = 100,
                                     thinning = 20,

```



```

num.steps = nsimulations,
neighborhood = c(0,1,0),
sizes.allowed = 1:n,
sizes.simulated = 1:n,
return.all.partitions = TRUE)

```

---

estimate\_ERPM

*Estimate ERPM*


---

### Description

Function to estimate a given model for a given observed partition. All options of the algorithm can be specified here.

### Usage

```

estimate_ERPM(
  partition,
  nodes,
  objects,
  effects,
  startingestimates,
  gainfactor = 0.1,
  a.scaling = 0.8,
  r.truncation.p1 = -1,
  r.truncation.p2 = -1,
  burnin = 30,
  thinning = 10,
  length.p1 = 100,
  min.iter.p2 = NULL,
  max.iter.p2 = NULL,
  multiplication.iter.p2 = 100,
  num.steps.p2 = 6,
  length.p3 = 1000,
  neighborhood = c(0.7, 0.3, 0),
  fixed.estimated = NULL,
  numgroups.allowed = NULL,
  numgroups.simulated = NULL,
  sizes.allowed = NULL,
  sizes.simulated = NULL,
  double.averaging = FALSE,
  inv.zcov = NULL,
  inv.scaling = NULL,
  parallel = FALSE,
  parallel2 = FALSE,
  cpus = 1,

```

```

    verbose = FALSE
  )

```

### Arguments

partition	observed partition
nodes	nodeset (data frame)
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
startingestimates	first guess for the model parameters
gainfactor	numeric used to decrease the size of steps made in the Newton optimization
a.scaling	numeric used to reduce the influence of non-diagonal elements in the scaling matrix (for stability)
r.truncation.p1	numeric used to limit extreme values in the covariance matrix (for stability)
r.truncation.p2	numeric used to limit extreme values in the covariance matrix (for stability)
burnin	integer for the number of burn-in steps before sampling
thining	integer for the number of thinning steps between sampling
length.p1	number of samples in phase 1
min.iter.p2	minimum number of sub-steps in phase 2
max.iter.p2	maximum number of sub-steps in phase 2
multiplication.iter.p2	value for the lengths of sub-steps in phase 2 (multiplied by $2.52^k$ )
num.steps.p2	number of optimisation steps in phase 2
length.p3	number of samples in phase 3
neighborhood	way of choosing partitions: probability vector (actors swap, merge/division, single actor move)
fixed.estimated	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)

double.averaging	option to average the statistics sampled in each sub-step of phase 2
inv.zcov	initial value of the inverted covariance matrix (if a phase 3 was run before) to bypass the phase 1
inv.scaling	initial value of the inverted scaling matrix (if a phase 3 was run before) to bypass the phase 1
parallel	whether the phase 1 and 3 should be parallelized
parallel2	whether there should be several phases 2 run in parallel
cpus	how many cores can be used
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

### Value

A list with the outputs of the three different phases of the algorithm

### Examples

```
# define an arbitrary set of n = 6 nodes with attributes, and an arbitrary covariate matrix
n <- 6
nodes <- data.frame(label = c("A", "B", "C", "D", "E", "F"),
                    gender = c(1,1,2,1,2,2),
                    age = c(20,22,25,30,30,31))
friendship <- matrix(c(0, 1, 1, 1, 0, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 0, 0,
                      0, 1, 1, 0, 0, 1,
                      0, 0, 0, 0, 1, 0), 6, 6, TRUE)

# choose the effects to be included (see manual for all effect names)
effects <- list(names = c("num_groups", "same", "diff", "tie"),
               objects = c("partition", "gender", "age", "friendship"))
objects <- list()
objects[[1]] <- list(name = "friendship", object = friendship)

# define observed partition
partition <- c(1,1,2,2,2,3)

# estimate
startingestimates <- c(-2,0,0,0)
estimation <- estimate_ERPM(partition,
                            nodes,
                            objects,
                            effects,
                            startingestimates = startingestimates,
                            burnin = 100,
                            thinning = 20,
                            length.p1 = 500, # number of samples in phase 1
```

```

multiplication.iter.p2 = 20, # iterations in phase 2
num.steps.p2 = 4, # number of phase 2 subphases
length.p3 = 1000) # number of samples in phase 3

# get results table
estimation

```

---

estimate\_logL

*Estimate log likelihood*


---

### Description

Function to estimate the log likelihood of a model for an observed partition

### Usage

```

estimate_logL(
  partition,
  nodes,
  effects,
  objects,
  theta,
  theta_0,
  M,
  num.steps,
  burnin,
  thinning,
  neighborhoods = c(0.7, 0.3, 0),
  numgroups.allowed = NULL,
  numgroups.simulated = NULL,
  sizes.allowed = NULL,
  sizes.simulated = NULL,
  logL_0 = NULL,
  parallel = FALSE,
  cpus = 1,
  verbose = FALSE
)

```

### Arguments

partition	observed partition
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")

theta	estimated model parameters
theta_0	model parameters if all other effects than "num-groups" are fixed to 0 (basic Dirichlet partition model)
M	number of steps in the path-sampling algorithm
num.steps	number of samples in each step
burnin	integer for the number of burn-in steps before sampling
thining	integer for the number of thinning steps between sampling
neighborhoods	= c(0.7,0.3,0) way of choosing partitions
numgroups.allowed	= NULL, # vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	= NULL, # vector containing the number of groups simulated
sizes.allowed	= NULL, vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	= NULL, vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
logL_0	= NULL, if known, the value of the log likelihood of the basic dirichlet model
parallel	= FALSE, indicating whether the code should be run in parallel
cpus	= 1, number of cpus required for the parallelization
verbose	= FALSE, to print the current step the algorithm is in

### Value

List with the log likelihood , AIC, lambda and the draws

### Examples

```
# estimate the log-likelihood and AIC of an estimated model (e.g. useful to compare two models)

# define an arbitrary set of n = 6 nodes with attributes, and an arbitrary covariate matrix
n <- 6
nodes <- data.frame(label = c("A", "B", "C", "D", "E", "F"),
                    gender = c(1, 1, 2, 1, 2, 2),
                    age = c(20, 22, 25, 30, 30, 31))
friendship <- matrix(c(0, 1, 1, 1, 0, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 1, 0,
                      1, 0, 0, 0, 0, 0,
                      0, 1, 1, 0, 0, 1,
                      0, 0, 0, 0, 1, 0), 6, 6, TRUE)

# choose the effects to be included (see manual for all effect names)
effects <- list(names = c("num_groups", "same", "diff", "tie"),
               objects = c("partition", "gender", "age", "friendship"))
```

```

objects <- list()
objects[[1]] <- list(name = "friendship", object = friendship)

# define observed partition
partition <- c(1,1,2,2,2,3)
# (an exemplary estimation is internally stored in order to save time)

# first: estimate the ML estimates of a simple model with only one parameter
# for number of groups (this parameter should be in the model!)
likelihood_function <- function(x){ exp(x*max(partition)) / compute_numgroups_denominator(n,x)}
curve(likelihood_function, from=-2, to=0)
parameter_base <- optimize(likelihood_function, interval=c(-2, 0), maximum=TRUE)
parameters_basemodel <- c(parameter_base$maximum,0,0,0)

# estimate logL and AIC
logL_AIC <- estimate_logL(partition,
                          nodes,
                          effects,
                          objects,
                          theta = estimation$results$est,
                          theta_0 = parameters_basemodel,
                          M = 3,
                          num.steps = 200,
                          burnin = 100,
                          thinning = 20)

logL_AIC$logL
logL_AIC$AIC

```

---

estimate\_multipleERPM *Estimate ERPM for multiple observations*

---

## Description

Function to estimate a given model for given observed (multiple) partitions. All options of the algorithm can be specified here.

## Usage

```

estimate_multipleERPM(
  partitions,
  presence.tables,
  nodes,
  objects,
  effects,
  startingestimates,
  gainfactor = 0.1,

```

```

a.scaling = 0.8,
r.truncation.p1 = -1,
r.truncation.p2 = -1,
burnin = 30,
thining = 10,
length.p1 = 100,
min.iter.p2 = NULL,
max.iter.p2 = NULL,
multiplication.iter.p2 = 200,
num.steps.p2 = 6,
length.p3 = 1000,
neighborhood = c(0.7, 0.3, 0),
fixed.estimated = NULL,
numgroups.allowed = NULL,
numgroups.simulated = NULL,
sizes.allowed = NULL,
sizes.simulated = NULL,
double.averaging = FALSE,
inv.zcov = NULL,
inv.scaling = NULL,
parallel = FALSE,
parallel2 = FALSE,
cpus = 1,
verbose = FALSE
)

```

### Arguments

partitions	observed partitions
presence.tables	XXX
nodes	nodeset (data frame)
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
startingestimates	first guess for the model parameters
gainfactor	numeric used to decrease the size of steps made in the Newton optimization
a.scaling	numeric used to reduce the influence of non-diagonal elements in the scaling matrix (for stability)
r.truncation.p1	numeric used to limit extreme values in the covariance matrix (for stability)
r.truncation.p2	numeric used to limit extreme values in the covariance matrix (for stability)
burnin	integer for the number of burn-in steps before sampling
thining	integer for the number of thining steps between sampling

length.p1	number of samples in phase 1
min.iter.p2	minimum number of sub-steps in phase 2
max.iter.p2	maximum number of sub-steps in phase 2
multiplication.iter.p2	value for the lengths of sub-steps in phase 2 (multiplied by $2.52^k$ )
num.steps.p2	number of optimisation steps in phase 2
length.p3	number of samples in phase 3
neighborhood	way of choosing partitions: probability vector (actors swap, merge/division, single actor move)
fixed.estimated	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
double.averaging	option to average the statistics sampled in each sub-step of phase 2
inv.zcov	initial value of the inverted covariance matrix (if a phase 3 was run before) to bypass the phase 1
inv.scaling	initial value of the inverted scaling matrix (if a phase 3 was run before) to bypass the phase 1
parallel	whether the phase 1 and 3 should be parallelized
parallel2	whether there should be several phases 2 run in parallel
cpus	how many cores can be used
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

### Value

A list with the outputs of the three different phases of the algorithm

### Examples

```
# define an arbitrary set of n = 6 nodes with attributes, and an arbitrary covariate matrix
n <- 6
nodes <- data.frame(label = c("A", "B", "C", "D", "E", "F"),
                    gender = c(1, 1, 2, 1, 2, 2),
```



```

age = c(20,22,25,30,30,31))
friendship <- matrix(c(0, 1, 1, 1, 0, 0,
                     1, 0, 0, 0, 1, 0,
                     1, 0, 0, 0, 1, 0,
                     1, 0, 0, 0, 0, 0,
                     0, 1, 1, 0, 0, 1,
                     0, 0, 0, 0, 1, 0), 6, 6, TRUE)

# specify whether nodes are present at different points of time
presence.tables <- matrix(c(1, 1, 1, 1, 1, 1,
                          0, 1, 1, 1, 1, 1,
                          1, 0, 1, 1, 1, 1), 6, 3)

# choose effects to be included in the estimated model
effects_multiple <- list(names = c("num_groups", "same", "diff", "tie", "inertia_1"),
                        objects = c("partitions", "gender", "age", "friendship", "partitions"),
                        objects2 = c("", "", "", "", ""))
objects_multiple <- list()
objects_multiple[[1]] <- list(name = "friendship", object = friendship)

# define the observation
partitions <- matrix(c(1, 1, 2, 2, 2, 3,
                     NA, 1, 1, 2, 2, 2,
                     1, NA, 2, 3, 3, 1), 6, 3)

# estimate
startingestimates <- c(-2,0,0,0,0)
estimation <- estimate_multipleERPM(partitions,
                                   presence.tables,
                                   nodes,
                                   objects_multiple,
                                   effects_multiple,
                                   startingestimates = startingestimates,
                                   burnin = 100,
                                   thinning = 50,
                                   gainfactor = 0.6,
                                   length.p1 = 200,
                                   multiplication.iter.p2 = 20,
                                   num.steps.p2 = 4,
                                   length.p3 = 1000)

# get results table
estimation

```

---

exactestimates\_numgroups

*Exact estimates number of groups*


---

**Description**

This function finds the best estimate for a model only including the statistics of number of groups. It does a grid search for a vector of potential parameters, for all numbers of groups.

**Usage**

```
exactestimates_numgroups(num.nodes, pmin, pmax, pinc)
```

**Arguments**

num.nodes	number of nodes
pmin	lowest parameter value
pmax	highest parameter value
pinc	increment between different parameter values

**Value**

a list

---

find\_all\_partitions    *Function to enumerate all possible partitions for a given n*

---

**Description**

Function to enumerate all possible partitions for a given n

**Usage**

```
find_all_partitions(n)
```

**Arguments**

n	number of nodes
---	-----------------

**Value**

matrix where each line corresponds to a possible partition

**Examples**

```
n <- 6  
all_partitions <- find_all_partitions(n)
```

---

 gridsearch\_burninthing\_multiple

*Grid - search burnin thinging multiple*


---

## Description

Function that simulates the Markov chain for a given model and several sets of transitions (the neighborhoods), for multiple partitions. For each neighborhood, it calculates the autocorrelation of statistics for different thinnings and the average statistics for different burn-ins. Then the best neighborhood can be selected along with good values for burn-in and thinning

## Usage

```
gridsearch_burninthing_multiple(
  partitions,
  presence.tables,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhoods,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  max.thinning,
  parallel = FALSE,
  cpus = 1
)
```

## Arguments

partitions	Observed partitions
presence.tables	Presence of nodes
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhoods	List of probability vectors (proba actors swap, proba merge/division, proba single actor move)

numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
max.thining	Where to stop adding thinning
parallel	False, to run different neighborhoods in parallel
cpus	Equal to 1

**Value**

list

---

gridsearch\_burninthing\_single

*Grid - search burnin thinning single*


---

**Description**

Function that simulates the Markov chain for a given model and several sets of transitions (the neighborhoods), for a single partition. For each neighborhood, it calculates the autocorrelation of statistics for different thinings and the average statistics for different burn-ins. Then the best neighborhood can be selected along with good values for burn-in and thinning

**Usage**

```
gridsearch_burninthing_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhoods,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  max.thining,
  parallel = FALSE,
  cpus = 1
)
```

**Arguments**

partition	A partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhoods	List of probability vectors (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
max.thining	Where to stop adding thinning
parallel	False, to run different neighborhoods in parallel
cpus	Equal to 1

**Value**

list

---

gridsearch\_burnin\_single

*Grid - search burnin single*


---

**Description**

Function that can be used to find a good length for the burn-in of the Markov chain for a given model and different sets of transitions in the chain (the neighborhoods). For each neighborhood, it draws a chain and calculates the mean statistics for different burn-ins.

**Usage**

```

gridsearch_burnin_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhoods,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  parallel = FALSE,
  cpus = 1
)

```

**Arguments**

partition	A partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhoods	List of probability vectors (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	= NULL, # vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
parallel	False, to run different neighborhoods in parallel
cpus	Equal to 1

**Value**

all simulations

---

```
gridsearch_thining_single
```

*Grid - search thining single*

---

## Description

Function that can be used to find a good length for the thining of the Markov chain for a given model and differents sets of transitions in the chain (the neighborhoods). For each neighborhood, it draws a chain and calculates the autocorrelation of statistics for different thining.

## Usage

```
gridsearch_thining_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhoods,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  burnin,
  max.thining,
  parallel = FALSE,
  cpus = 1
)
```

## Arguments

partition	A partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhoods	List of probability vectors (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)

numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
burnin	length of the burn-in period
max.thining	maximal value for the thinning to be tested
parallel	False, to run different neighborhoods in parallel
cpus	Equal to 1

**Value**

all simulations

---

group_size	<i>Statistics on the size of groups in a partition</i>
------------	--

---

**Description**

This function computes the average or the standard deviation of the size of groups in a partition.

**Usage**

```
group_size(partition, stat)
```

**Arguments**

partition	A partition (vector)
stat	The statistic to compute : 'avg' for average and 'sd' for standard deviation

**Value**

A number corresponding to the correlation coefficient if the attribute is numerical or the correlation ratio if the attribute is categorical.

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
group_size(p, 'avg')
group_size(p, 'sd')
```



---

icc *Intra class correlation*

---

### Description

This function computes the intra class correlation correlation of attributes for 2 randomly drawn individuals in the same group.

### Usage

```
icc(partition, attribute)
```

### Arguments

partition	A partition
attribute	A vector containing the values of the attribute

### Value

A number corresponding to the ICC

### Examples

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
icc(p, at)
```

---

number\_categories *Number of individuals having an attribute*

---

### Description

This function computes the total number of individuals being in a category of an attribute in a partition. It also computes the sum of the proportion in each group of individuals being in a category.

### Usage

```
number_categories(partition, attribute, stat, category)
```

### Arguments

partition	A partition (vector)
attribute	A vector containing the values of the attribute
stat	The statistic to compute : 'avg' for the sum of proportion per group and 'sum' for the total number
category	The category to consider or category = 'all' if all categories have to be considered

**Value**

The statistic chosen in stat depending on the value of category. If category = 'all', returns a vector.

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(1,0,0,0,1,1,0,0,1)
number_categories(p,at,'avg','all')
```

---

number\_ties

*Same pairs of individuals in a partition*

---

**Description**

This function computes the number of ties.

**Usage**

```
number_ties(partition, dyadic_attribute, stat)
```

**Arguments**

partition	A partition (vector)
dyadic_attribute	A matrix containing the values of the attribute
stat	The statistic to compute : 'avg_pergroup' for the average per group , 'sum_pergroup' for the sum, 'sum_perind' and 'avg_perind' for the number of ties per individuals each individual has in its group.

**Value**

The statistic chosen in stat

**Examples**

```
p <- c(1,2,2,3,3,4)
v <- c(0,0,0,0,0,1,0,0,1,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
at <- matrix(v,6,6, byrow = TRUE)
number_ties(p,at,'avg_pergroup')
```

---

order_groupids	<i>Function to replace the ids of the group without forgetting an id and put in the first appearance order for example: [2 1 1 4 2] becomes [1 2 2 3 1]</i>
----------------	---

---

**Description**

Function to replace the ids of the group without forgetting an id and put in the first appearance order for example: [2 1 1 4 2] becomes [1 2 2 3 1]

**Usage**

```
order_groupids(partition)
```

**Arguments**

partition      observed partition

**Value**

a vector (partition)

---

outcomeObjects	<i>Exemplary outcome objects for the ERPM Package</i>
----------------	---

---

**Description**

These are exemplary outcome objects for the ERPM package and can be used in order not to run all precedent functions and thus save time. The following products are provided:

**Format**

estimation An results object created by the function `estimate_ERPM()`.

---

phase1                      *Core function for Phase 1*

---

### Description

Core function for Phase 1

### Usage

```
phase1(
  startingestimates,
  inv.zcov,
  inv.scaling,
  z.phase1,
  z.obs,
  nodes,
  effects,
  objects,
  r.truncation.p1,
  length.p1,
  fixed.estimated,
  verbose = FALSE
)
```

### Arguments

startingestimates	vector containing initial parameter values
inv.zcov	inverted covariance matrix
inv.scaling	scaling matrix
z.phase1	statistics retrieved from phase 1
z.obs	observed statistics
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
r.truncation.p1	numeric used to limit extreme values in the covariance matrix (for stability)
length.p1	number of samples in phase 1
fixed.estimated	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

estimated parameters after phase 1

---

plot\_averagesizes      *Plot average sizes*

---

**Description**

Function to plot the average size of a random partition depending on the number of nodes

**Usage**

plot\_averagesizes(nmin, nmax, ninc)

**Arguments**

nmin	minimum number of nodes
nmax	maximum number of nodes
ninc	increment between the different number of nodes

**Value**

a vector

---

plot\_numgroups\_likelihood  
*Plot likelihood of number groups*

---

**Description**

Function to plot the log-likelihood of the model with a single statistic (number of groups) depending on the parameter value for this statistic

**Usage**

plot\_numgroups\_likelihood(m.obs, num.nodes, pmin, pmax, pinc)

**Arguments**

m.obs	observed number of groups
num.nodes	number of nodes
pmin	lowest parameter value
pmax	highest parameter value
pinc	increment between different parameter values

**Value**

a vector

---

plot_partition	<i>Visualization of partition</i>
----------------	-----------------------------------

---

**Description**

This function plot the groups of a partition

**Usage**

```
plot_partition(
  partition,
  title = NULL,
  group.color = NULL,
  attribute.color = NULL,
  attribute.shape = NULL
)
```

**Arguments**

partition	A partition (vector)
title	Character, the title of the plot (default=NULL)
group.color	A vector with the colors of the groups (default=NULL)
attribute.color	A vector, attribute to represent with colors (default=NULL)
attribute.shape	A vector, attribute to represent with shapes (default=NULL)

**Value**

A plot of the partition

**Examples**

```
p <- c(1,1,1,2,2,2,2,3,3,3,4,4,4,4,4)
attr1 <- c(1,0,0,1,0,0,1,0,1,0,1,1,1,1,2)
attr2 <- c(1,1,1,1,0,0,3,0,1,0,1,1,1,1,2)
plot_partition(p,attribute.color = attr1, attribute.shape = attr2)
```

---

```
print.results.bayesian.erpm
    Print results of bayesian estimation (beta version)
```

---

**Description**

Print results of bayesian estimation (beta version)

**Usage**

```
## S3 method for class 'results.bayesian.erpm'
print(x, ...)
```

**Arguments**

x                    output of the bayesian estimate function  
...                   For internal use only.

**Value**

a data frame

---

```
print.results.list.erpm
    Print estimation results
```

---

**Description**

Print estimation results

**Usage**

```
## S3 method for class 'results.list.erpm'
print(x, ...)
```

**Arguments**

x                    output of the estimate function  
...                   For internal use only.

**Value**

a data frame

---

```
print.results.p3.erpm Print results of estimation of phase 3
```

---

**Description**

Print results of estimation of phase 3

**Usage**

```
## S3 method for class 'results.p3.erpm'
print(x, ...)
```

**Arguments**

x	output of the estimate function
...	For internal use only.

**Value**

a data frame

---

```
proportion_isolate Proportion of isolates
```

---

**Description**

This function computes the proportion of individuals not joining others.

**Usage**

```
proportion_isolate(partition)
```

**Arguments**

partition	A partition (vector)
-----------	----------------------

**Value**

A number corresponding to proportion of individuals alone.

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
proportion_isolate(p)
```



---

range_attribute	<i>Range of attribute in groups</i>
-----------------	-------------------------------------

---

**Description**

This function computes the sum or the average range of an attribute for groups in a partition.

**Usage**

```
range_attribute(partition, attribute, stat)
```

**Arguments**

partition	A partition (vector)
attribute	A vector containing the values of the attribute
stat	The statistic to compute : 'avg_pergroup' for the average per group and 'sum_pergroup' for the sum of the ranges

**Value**

The statistic chosen in stat

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
range_attribute(p,at,'avg_pergroup')
```

---

run_phase1_multiple	<i>Phase 1 wrapper for multiple observations</i>
---------------------	--

---

**Description**

Phase 1 wrapper for multiple observations

**Usage**

```
run_phase1_multiple(
  partitions,
  startingestimates,
  z.obs,
  presence.tables,
  nodes,
  effects,
  objects,
```

```

burnin,
thining,
gainfactor,
a.scaling,
r.truncation.p1,
length.p1,
neighborhood,
fixed.estimated,
numgroups.allowed,
numgroups.simulated,
sizes.allowed,
sizes.simulated,
parallel = FALSE,
cpus = 1,
verbose = FALSE
)

```

### Arguments

partitions	observed partitions
startingestimates	vector containing initial parameter values
z.obs	observed statistics
presence.tables	data frame to indicate which times nodes are present in the partition
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
burnin	integer for the number of burn-in steps before sampling
thining	integer for the number of thinning steps between sampling
gainfactor	gain factor (useless now)
a.scaling	scaling factor
r.truncation.p1	truncation factor (for stability)
length.p1	number of samples for phase 1
neighborhood	vector for the probability of choosing a particular transition in the chain
fixed.estimated	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated

sizes.allowed	vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
parallel	boolean to indicate whether the code should be run in parallel
cpus	number of cpus if parallel = TRUE
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list

---

run_phase1_single	<i>Phase 1 wrapper for single observation</i>
-------------------	---

---

**Description**

Phase 1 wrapper for single observation

**Usage**

```
run_phase1_single(
  partition,
  startingestimates,
  z.obs,
  nodes,
  effects,
  objects,
  burnin,
  thinning,
  gainfactor,
  a.scaling,
  r.truncation.p1,
  length.p1,
  neighborhood,
  fixed.estimates,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  parallel = TRUE,
  cpus = 1,
  verbose = FALSE
)
```

**Arguments**

<code>partition</code>	observed partition
<code>startingestimates</code>	vector containing initial parameter values
<code>z.obs</code>	observed statistics
<code>nodes</code>	node set (data frame)
<code>effects</code>	effects/sufficient statistics (list with a vector "names", and a vector "objects")
<code>objects</code>	objects used for statistics calculation (list with a vector "name", and a vector "object")
<code>burnin</code>	integer for the number of burn-in steps before sampling
<code>thining</code>	integer for the number of thinning steps between sampling
<code>gainfactor</code>	gain factor (useless now)
<code>a.scaling</code>	scaling factor
<code>r.truncation.p1</code>	truncation factor (for stability)
<code>length.p1</code>	number of samples for phase 1
<code>neighborhood</code>	vector for the probability of choosing a particular transition in the chain
<code>fixed.estimates</code>	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
<code>numgroups.allowed</code>	vector containing the number of groups allowed in the partition (now, it only works with vectors like <code>num_min:num_max</code> )
<code>numgroups.simulated</code>	vector containing the number of groups simulated
<code>sizes.allowed</code>	vector of group sizes allowed in sampling (now, it only works for vectors like <code>size_min:size_max</code> )
<code>sizes.simulated</code>	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like <code>size_min:size_max</code> )
<code>parallel</code>	boolean to indicate whether the code should be run in parallel
<code>cpus</code>	number of cpus if <code>parallel = TRUE</code>
<code>verbose</code>	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list

---

run\_phase2\_multiple     *Phase 2 wrapper for multiple observation*

---

### Description

Phase 2 wrapper for multiple observation

### Usage

```
run_phase2_multiple(  
  partitions,  
  estimates.phase1,  
  inv.zcov,  
  inv.scaling,  
  z.obs,  
  presence.tables,  
  nodes,  
  effects,  
  objects,  
  burnin,  
  thinning,  
  num.steps,  
  gainfactors,  
  r.truncation.p2,  
  min.iter,  
  max.iter,  
  multiplication.iter,  
  neighborhood,  
  fixed.estimated,  
  numgroups.allowed,  
  numgroups.simulated,  
  sizes.allowed,  
  sizes.simulated,  
  double.averaging,  
  parallel = FALSE,  
  cpus = 1,  
  verbose = FALSE  
)
```

### Arguments

partitions	observed partitions
estimates.phase1	vector containing parameter values after phase 1
inv.zcov	inverted covariance matrix
inv.scaling	scaling matrix

<code>z.obs</code>	observed statistics
<code>presence.tables</code>	data frame to indicate which times nodes are present in the partition
<code>nodes</code>	node set (data frame)
<code>effects</code>	effects/sufficient statistics (list with a vector "names", and a vector "objects")
<code>objects</code>	objects used for statistics calculation (list with a vector "name", and a vector "object")
<code>burnin</code>	integer for the number of burn-in steps before sampling
<code>thining</code>	integer for the number of thinning steps between sampling
<code>num.steps</code>	number of sub-phases in phase 2
<code>gainfactors</code>	vector of gain factors
<code>r.truncation.p2</code>	truncation factor
<code>min.iter</code>	minimum numbers of steps in each subphase
<code>max.iter</code>	maximum numbers of steps in each subphase
<code>multiplication.iter</code>	used to calculate <code>min.iter</code> and <code>max.iter</code> if not specified
<code>neighborhood</code>	vector for the probability of choosing a particular transition in the chain
<code>fixed.estimated</code>	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
<code>numgroups.allowed</code>	vector containing the number of groups allowed in the partition (now, it only works with vectors like <code>num_min:num_max</code> )
<code>numgroups.simulated</code>	vector containing the number of groups simulated
<code>sizes.allowed</code>	vector of group sizes allowed in sampling (now, it only works for vectors like <code>size_min:size_max</code> )
<code>sizes.simulated</code>	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like <code>size_min:size_max</code> )
<code>double.averaging</code>	boolean to indicate whether we follow the double-averaging procedure (often leads to better convergence)
<code>parallel</code>	boolean to indicate whether the code should be run in parallel
<code>cpus</code>	number of cpus if <code>parallel = TRUE</code>
<code>verbose</code>	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list

---

run\_phase2\_single      *Phase 2 wrapper for single observation*

---

### Description

Phase 2 wrapper for single observation

### Usage

```
run_phase2_single(  
  partition,  
  estimates.phase1,  
  inv.zcov,  
  inv.scaling,  
  z.obs,  
  nodes,  
  effects,  
  objects,  
  burnin,  
  thinning,  
  num.steps,  
  gainfactors,  
  r.truncation.p2,  
  min.iter,  
  max.iter,  
  multiplication.iter,  
  neighborhood,  
  fixed.estimated,  
  numgroups.allowed,  
  numgroups.simulated,  
  sizes.allowed,  
  sizes.simulated,  
  double.averaging,  
  parallel = FALSE,  
  cpus = 1,  
  verbose = FALSE  
)
```

### Arguments

partition	observed partition
estimates.phase1	vector containing parameter values after phase 1
inv.zcov	inverted covariance matrix
inv.scaling	scaling matrix
z.obs	observed statistics

<code>nodes</code>	node set (data frame)
<code>effects</code>	effects/sufficient statistics (list with a vector "names", and a vector "objects")
<code>objects</code>	objects used for statistics calculation (list with a vector "name", and a vector "object")
<code>burnin</code>	integer for the number of burn-in steps before sampling
<code>thining</code>	integer for the number of thinning steps between sampling
<code>num.steps</code>	number of sub-phases in phase 2
<code>gainfactors</code>	vector of gain factors
<code>r.truncation.p2</code>	truncation factor
<code>min.iter</code>	minimum numbers of steps in each subphase
<code>max.iter</code>	maximum numbers of steps in each subphase
<code>multiplication.iter</code>	used to calculate <code>min.iter</code> and <code>max.iter</code> if not specified
<code>neighborhood</code>	vector for the probability of choosing a particular transition in the chain
<code>fixed.estimated</code>	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
<code>numgroups.allowed</code>	vector containing the number of groups allowed in the partition (now, it only works with vectors like <code>num_min:num_max</code> )
<code>numgroups.simulated</code>	vector containing the number of groups simulated
<code>sizes.allowed</code>	vector of group sizes allowed in sampling (now, it only works for vectors like <code>size_min:size_max</code> )
<code>sizes.simulated</code>	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like <code>size_min:size_max</code> )
<code>double.averaging</code>	boolean to indicate whether we follow the double-averaging procedure (often leads to better convergence)
<code>parallel</code>	boolean to indicate whether the code should be run in parallel
<code>cpus</code>	number of cpus if <code>parallel = TRUE</code>
<code>verbose</code>	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list



---

run\_phase3\_multiple     *Phase 3 wrapper for multiple observation*

---

### Description

Phase 3 wrapper for multiple observation

### Usage

```
run_phase3_multiple(  
  partitions,  
  estimates.phase2,  
  z.obs,  
  presence.tables,  
  nodes,  
  effects,  
  objects,  
  burnin,  
  thinning,  
  a.scaling,  
  length.p3,  
  neighborhood,  
  numgroups.allowed,  
  numgroups.simulated,  
  sizes.allowed,  
  sizes.simulated,  
  fixed.estimates,  
  parallel = FALSE,  
  cpus = 1,  
  verbose = FALSE  
)
```

### Arguments

partitions	observed partitions
estimates.phase2	vector containing parameter values after phase 2
z.obs	observed statistics
presence.tables	data frame to indicate which times nodes are present in the partition
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
burnin	integer for the number of burn-in steps before sampling

thining	integer for the number of thinning steps between sampling
a.scaling	multiplicative factor for out-of-diagonal elements of the covariance matrix
length.p3	number of samples in phase 3
neighborhood	vector for the probability of choosing a particular transition in the chain
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
fixed.estimates	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
parallel	boolean to indicate whether the code should be run in parallel
cpus	number of cpus if parallel = TRUE
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list

---

run\_phase3\_single      *Phase 3 wrapper for single observation*

---

**Description**

Phase 3 wrapper for single observation

**Usage**

```
run_phase3_single(
  partition,
  estimates.phase2,
  z.obs,
  nodes,
  effects,
  objects,
  burnin,
  thinning,
```

```

    a.scaling,
    length.p3,
    neighborhood,
    numgroups.allowed,
    numgroups.simulated,
    sizes.allowed,
    sizes.simulated,
    fixed.estimates,
    parallel = FALSE,
    cpus = 1,
    verbose = FALSE
)

```

### Arguments

partition	observed partition
estimates.phase2	vector containing parameter values after phase 2
z.obs	observed statistics
nodes	node set (data frame)
effects	effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	objects used for statistics calculation (list with a vector "name", and a vector "object")
burnin	integer for the number of burn-in steps before sampling
thining	integer for the number of thinning steps between sampling
a.scaling	multiplicative factor for out-of-diagonal elements of the covariance matrix
length.p3	number of sampled partitions in phase 3
neighborhood	vector for the probability of choosing a particular transition in the chain
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
fixed.estimates	if some parameters are fixed, list with as many elements as effects, these elements equal a fixed value if needed, or NULL if they should be estimated
parallel	boolean to indicate whether the code should be run in parallel
cpus	number of cpus if parallel = TRUE
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

a list

---

same_pairs	<i>Same pairs of individuals in a partition</i>
------------	---

---

**Description**

This function computes the total number, the average number having the same value of a categorical variable and the number of individuals a partition.

**Usage**

```
same_pairs(partition, attribute, stat)
```

**Arguments**

partition	A partition (vector)
attribute	A vector containing the values of the attribute
stat	The statistic to compute : 'avg_pergroup' for the average, 'sum_pergroup' for the sum, 'sum_perind' and 'avg_perind' for the number of ties per individual each individual has in its group.

**Value**

The statistic chosen in stat

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(0,1,1,1,1,0,0,0,0)
same_pairs(p,at,'avg_pergroup')
```

---

similar_pairs	<i>Similar pairs of individuals in a partition</i>
---------------	--

---

**Description**

This function computes the total number, the average number having the close values of a numerical variable and the number of individuals a partition.

**Usage**

```
similar_pairs(partition, attribute, stat, threshold)
```

**Arguments**

partition	A partition (vector)
attribute	A vector containing the values of the attribute
stat	The statistic to compute : 'avg_pergroup' for the average, 'sum_pergroup' for the sum, 'sum_perind' and 'avg_perind' for individuals
threshold	Threshold to determine if 2 individuals attributes values are close

**Value**

The statistic chosen in stat

**Examples**

```
p <- c(1,2,2,3,3,4,4,4,5)
at <- c(3,5,23,2,1,0,3,9,2)
similar_pairs(p,at,1,'avg_pergroup')
```

---

simulate\_burninthing\_multiple

*Simulate burnin thinging multiple*

---

**Description**

Function that simulates the Markov chain for a given model and a set of transitions (the neighborhood), for multiple partitions. It calculates the autocorrelation of statistics for different thining and the average statistics for different burn-ins.

**Usage**

```
simulate_burninthing_multiple(
  partitions,
  presence.tables,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhood,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  max.thining,
  verbose = FALSE
)
```

**Arguments**

partitions	Observed partitions
presence.tables	to indicate which nodes were present when
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhood	Way of choosing partitions: probability vector (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
max.thining	maximal number of simulated steps in the thinning
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

A list

---

simulate\_burninthing\_single  
*Simulate burnin thinning single*

---

**Description**

Function that simulates the Markov chain for a given model and a set of transitions (the neighborhood), for a single partition. It calculates the autocorrelation of statistics for different thinings and the average statistics for different burn-ins.

**Usage**

```
simulate_burninthinging_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhood,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  max.thining,
  verbose = FALSE
)
```

**Arguments**

partition	Observed partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhood	Way of choosing partitions: probability vector (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
max.thining	maximal number of simulated steps in the thinning
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

A list

---

 simulate\_burnin\_single

*Simulate burn in single*


---

### Description

Function that can be used to find a good length for the burn-in of the Markov chain for a given model and a given set of transitions in the chain (the neighborhood). It draws a chain and calculates the mean statistics for different burn-ins.

### Usage

```
simulate_burnin_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhood,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated
)
```

### Arguments

partition	A partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted
neighborhood	Way of choosing partitions: probability vector (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)



sizes.simulated

Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size\_min:size\_max)

### Value

A list with list the draws, the moving.means and the moving means smoothed

---

simulate\_thining\_single

*Simulate thining single*

---

### Description

Function that can be used to find a good length for the thining of the Markov chain for a given model and a set of transitions in the chain (the neighborhood). It draws a chain and calculates the autocorrelation of statistics for different thinings.

### Usage

```
simulate_thining_single(
  partition,
  theta,
  nodes,
  effects,
  objects,
  num.steps,
  neighborhood,
  numgroups.allowed,
  numgroups.simulated,
  sizes.allowed,
  sizes.simulated,
  burnin,
  max.thining,
  verbose = FALSE
)
```

### Arguments

partition	A partition (vector)
theta	Initial model parameters
nodes	Node set (data frame)
effects	Effects/sufficient statistics (list with a vector "names", and a vector "objects")
objects	Objects used for statistics calculation (list with a vector "name", and a vector "object")
num.steps	Number of samples wanted

neighborhood	Way of choosing partitions: probability vector (proba actors swap, proba merge/division, proba single actor move)
numgroups.allowed	vector containing the number of groups allowed in the partition (now, it only works with vectors like num_min:num_max)
numgroups.simulated	vector containing the number of groups simulated
sizes.allowed	Vector of group sizes allowed in sampling (now, it only works for vectors like size_min:size_max)
sizes.simulated	Vector of group sizes allowed in the Markov chain but not necessarily sampled (now, it only works for vectors like size_min:size_max)
burnin	number of simulated steps for the burn-in
max.thining	maximal number of simulated steps in the thinning
verbose	logical: should intermediate results during the estimation be printed or not? Defaults to FALSE.

**Value**

A list

---

Stirling2\_constraints *Function to calculate the number of partitions with k groups of sizes between smin and smax*

---

**Description**

Function to calculate the number of partitions with k groups of sizes between smin and smax

**Usage**

```
Stirling2_constraints(n, k, smin, smax)
```

**Arguments**

n	number of nodes
k	number of groups
smin	minimum group size possible in the partition
smax	maximum group size possible in the partition

**Value**

a numeric

**Examples**

```
n <- 6
k <- 2
size_min <- 2
size_max <- 4
Stirling2_constraints(n,k,size_min,size_max)
```

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