

Package ‘tidygraph’

July 7, 2017

Type Package

Title A Tidy API for Graph Manipulation

Version 1.0.0

Date 2017-07-06

Author Thomas Lin Pedersen

Maintainer Thomas Lin Pedersen <thomasp85@gmail.com>

Description A graph, while not “tidy” in itself, can be thought of as two tidy data frames describing node and edge data respectively. ‘tidygraph’ provides an approach to manipulate these two virtual data frames using the API defined in the ‘dplyr’ package, as well as provides tidy interfaces to a lot of common graph algorithms.

License GPL (>= 2)

Encoding UTF-8

LazyData true

RoxygenNote 6.0.1

Imports tibble, dplyr (>= 0.7), igraph, magrittr, utils, rlang, R6, Rcpp, tools, stats, tidyr

URL <https://github.com/thomasp85/tidygraph>

BugReports <https://github.com/thomasp85/tidygraph/issues>

LinkingTo Rcpp

Suggests network, data.tree, ape, graph, methods, testthat, covr

NeedsCompilation yes

Repository CRAN

Date/Publication 2017-07-07 05:01:15 UTC

R topics documented:

activate	2
as_tbl_graph.data.frame	3

bind_graphs	6
centrality	7
component_games	9
context_accessors	10
create_graphs	11
edge_types	13
evolution_games	13
graph_join	15
graph_measures	16
group_graph	19
local_graph	21
map_bfs	22
map_bfs_back	24
map_dfs	26
map_dfs_back	27
map_local	29
morph	30
morphers	31
node_measures	34
node_topology	35
node_types	35
pair_measures	37
reroute	38
sampling_games	39
search_graph	41
type_games	42
Index	44

activate

Determine the context of subsequent manipulations

Description

As a `tbl_graph` can be considered as a collection of two linked tables it is necessary to specify which table is referenced during manipulations. The `activate` verb does just that and needs affects all subsequent manipulations until a new table is activated. `active` is a simple query function to get the currently active context.

Usage

```
activate(.data, what)
```

```
active(x)
```

Arguments

.data, x A tbl_graph or a grouped_tbl_graph
 what What should get activated? Possible values are nodes or edges.

Value

A tbl_graph

Note

Activate will ungroup a grouped_tbl_graph.

Examples

```
gr <- create_complete(5) %>%
  activate(nodes) %>%
  mutate(class = sample(c('a', 'b'), 5, TRUE)) %>%
  activate(edges) %>%
  arrange(from)
```

as_tbl_graph.data.frame

A data structure for tidy graph manipulation

Description

The `tbl_graph` class is a thin wrapper around an `igraph` object that provides methods for manipulating the graph using the tidy API. As it is just a subclass of `igraph` every `igraph` method will work as expected. A `grouped_tbl_graph` is the equivalent of a `grouped_df` where either the nodes or the edges has been grouped. The `grouped_tbl_graph` is not constructed directly but by using the `group_by()` verb. After creation of a `tbl_graph` the nodes are activated by default. The context can be changed using the `activate()` verb and affects all subsequent operations. Changing context automatically drops any grouping. The current active context can always be extracted with `as_tibble()`, which drops the graph structure and just returns a `tbl_df` or a `grouped_df` depending on the state of the `tbl_graph`. The returned context can be overridden by using the `active` argument in `as_tibble()`.

Usage

```
## S3 method for class 'data.frame'
as_tbl_graph(x, directed = TRUE, ...)

## S3 method for class 'Node'
as_tbl_graph(x, directed = TRUE, mode = "out", ...)

## S3 method for class 'dendrogram'
```

```

as_tbl_graph(x, directed = TRUE, mode = "out", ...)

## S3 method for class 'graphNEL'
as_tbl_graph(x, ...)

## S3 method for class 'graphAM'
as_tbl_graph(x, ...)

## S3 method for class 'graphBAM'
as_tbl_graph(x, ...)

## S3 method for class 'hclust'
as_tbl_graph(x, directed = TRUE, mode = "out", ...)

## S3 method for class 'igraph'
as_tbl_graph(x, ...)

## S3 method for class 'list'
as_tbl_graph(x, directed = TRUE, ...)

## S3 method for class 'matrix'
as_tbl_graph(x, directed = TRUE, ...)

## S3 method for class 'network'
as_tbl_graph(x, ...)

## S3 method for class 'phylo'
as_tbl_graph(x, directed = NULL, ...)

## S3 method for class 'evonet'
as_tbl_graph(x, directed = TRUE, ...)

tbl_graph(nodes = NULL, edges = NULL, directed = TRUE)

as_tbl_graph(x, ...)

## Default S3 method:
as_tbl_graph(x, ...)

is.tbl_graph(x)

```

Arguments

<code>x</code>	An object convertible to a <code>tbl_graph</code>
<code>directed</code>	Should the constructed graph be directed (defaults to TRUE)
<code>...</code>	Arguments passed on to the conversion function
<code>mode</code>	In case <code>directed = TRUE</code> should the edge direction be away from node or towards. Possible values are "out" (default) or "in".

nodes	A data.frame containing information about the nodes in the graph.
edges	A data.frame containing information about the edges in the graph. The terminal nodes of each edge must either be encoded in a to and from column, or in the two first columns, as integers.

Details

Constructors are provided for most data structures that resembles networks. If a class provides an `igraph::as.igraph()` method it is automatically supported.

Value

A `tbl_graph` object

Methods (by generic)

- `as_tbl_graph`: Method for edge table
- `as_tbl_graph`: Method to deal with Node objects from the `data.tree` package
- `as_tbl_graph`: Method for dendrogram objects
- `as_tbl_graph`: Method for handling graphNEL objects from the `graph` package (on Bioconductor)
- `as_tbl_graph`: Method for handling graphAM objects from the `graph` package (on Bioconductor)
- `as_tbl_graph`: Method for handling graphBAM objects from the `graph` package (on Bioconductor)
- `as_tbl_graph`: Method for hclust objects
- `as_tbl_graph`: Method for igraph object. Simply subclasses the object into a `tbl_graph`
- `as_tbl_graph`: Method for adjacency lists and lists of node and edge tables
- `as_tbl_graph`: Method for edgelist, adjacency and incidence matrices
- `as_tbl_graph`: Method to handle network objects from the `network` package. Requires this packages to work.
- `as_tbl_graph`: Method for handling phylo objects from the `ape` package
- `as_tbl_graph`: Method for handling evonet objects from the `ape` package
- `as_tbl_graph`: Default method. tries to call `igraph::as.igraph()` on the input.

`bind_graphs`*Add graphs, nodes, or edges to a `tbl_graph`*

Description

These functions are `tbl_graph` pendants to `dplyr::bind_rows()` that allows you to grow your `tbl_graph` by adding rows to either the nodes data, the edges data, or both. As with `bind_rows()` columns are matched by name and are automatically filled with NA if the column doesn't exist in some instances. In the case of `bind_graphs()` the graphs are automatically converted to `tbl_graph` objects prior to binding. The edges in each graph will continue to reference the nodes in the graph where they originated, meaning that their terminal node indexes will be shifted to match the new index of the node in the combined graph. This means the `bind_graphs()` always result in a disconnected graph. See `graph_join()` for merging graphs on common nodes.

Usage

```
bind_graphs(.data, ...)
```

```
bind_nodes(.data, ...)
```

```
bind_edges(.data, ...)
```

Arguments

<code>.data</code>	A <code>tbl_graph</code>
<code>...</code>	In case of <code>bind_nodes()</code> and <code>bind_edges()</code> data.frames to add. In the case of <code>bind_graphs()</code> objects that are convertible to <code>tbl_graph</code> using <code>as_tbl_graph()</code> .

Value

A `tbl_graph` containing the new data

Examples

```
graph <- create_notable('bull')
new_graph <- create_notable('housex')

# Add nodes
graph %>% bind_nodes(data.frame(new = 1:4))

# Add edges
graph %>% bind_edges(data.frame(from = 1, to = 4:5))

# Add graphs
graph %>% bind_graphs(new_graph)
```

`centrality`*Calculate node and edge centrality*

Description

The centrality of a node measures the importance of node in the network. As the concept of importance is ill-defined and dependent on the network and the questions under consideration, many centrality measures exist. `tidygraph` provides a consistent set of wrappers for all the centrality measures implemented in `igraph` for use inside `dplyr::mutate()` and other relevant verbs. All functions provided by `tidygraph` have a consistent naming scheme and automatically calls the function on the graph, returning a vector with measures ready to be added to the node data.

Usage

```
centrality_alpha(weights = NULL, alpha = 1, exo = 1, tol = 1e-07,
  loops = FALSE)

centrality_authority(weights = NULL, scale = TRUE,
  options = igraph::arpack_defaults)

centrality_betweenness(weights = NULL, directed = TRUE, cutoff = NULL,
  nobigint = TRUE, normalized = FALSE)

centrality_power(exponent = 1, rescale = FALSE, tol = 1e-07,
  loops = FALSE)

centrality_closeness(weights = NULL, mode = "out", normalized = FALSE,
  cutoff = NULL)

centrality_eigen(weights = NULL, directed = FALSE, scale = TRUE,
  options = igraph::arpack_defaults)

centrality_hub(weights = NULL, scale = TRUE,
  options = igraph::arpack_defaults)

centrality_pagerank(weights = NULL, directed = TRUE, damping = 0.85,
  personalized = NULL)

centrality_subgraph(loops = FALSE)

centrality_degree(weights = NULL, mode = "out", loops = TRUE,
  normalized = FALSE)

centrality_edge_betweenness(weights = NULL, directed = TRUE,
  cutoff = NULL)
```

Arguments

weights	The weight of the edges to use for the calculation. Will be evaluated in the context of the edge data.
alpha	Relative importance of endogenous vs exogenous factors
exo	The exogenous factors of the nodes. Either a scalar or a number number for each node. Evaluated in the context of the node data.
tol	Tolerance for near-singularities during matrix inversion
loops	Should loops be included in the calculation
scale	Should the output be scaled between 0 and 1
options	Settings passed on to <code>igraph::arpack()</code>
directed	Should direction of edges be used for the calculations
cutoff	maximum path length to use during calculations
nobigint	Should big integers be avoided during calculations
normalized	Should the output be normalized
exponent	The decay rate for the Bonacich power centrality
rescale	Should the output be scaled to sum up to 1
mode	How should edges be followed. Ignored for undirected graphs
damping	The damping factor of the page rank algorithm
personalized	The probability of jumping to a node when abandoning a random walk. Evaluated in the context of the node data.

Value

A numeric vector giving the centrality measure of each node.

Functions

- `centrality_alpha`: Wrapper for `igraph::alpha_centrality()`
- `centrality_authority`: Wrapper for `igraph::authority_score()`
- `centrality_betweenness`: Wrapper for `igraph::betweenness()` and `igraph::estimate_betweenness()`
- `centrality_power`: Wrapper for `igraph::power_centrality()`
- `centrality_closeness`: Wrapper for `igraph::closeness()` and `igraph::estimate_closeness()`
- `centrality_eigen`: Wrapper for `igraph::eigen_centrality()`
- `centrality_hub`: Wrapper for `igraph::hub_score()`
- `centrality_pagerank`: Wrapper for `igraph::page_rank()`
- `centrality_subgraph`: Wrapper for `igraph::subgraph_centrality()`
- `centrality_degree`: Wrapper for `igraph::degree()` and `igraph::strength()`
- `centrality_edge_betweenness`: Wrapper for `igraph::edge_betweenness()`

Examples

```

create_notable('bull') %>%
  activate(nodes) %>%
  mutate(importance = centrality_alpha())

# Most centrality measures are for nodes but not all
create_notable('bull') %>%
  activate(edges) %>%
  mutate(importance = centrality_edge_betweenness())

```

component_games *Graph games based on connected components*

Description

This set of graph creation algorithms simulate the topology by, in some way, connecting subgraphs. The nature of their algorithm is described in detail at the linked [igraph documentation](#).

Usage

```

play_blocks(n, size_blocks, p_between, directed = TRUE, loops = FALSE)

play_blocks_hierarchy(n, size_blocks, rho, p_within, p_between)

play_islands(n_islands, size_islands, p_within, m_between)

play_smallworld(n_dim, dim_size, order, p_rewire, loops = FALSE,
  multiple = FALSE)

```

Arguments

n	The number of nodes in the graph.
size_blocks	The number of vertices in each block
p_between, p_within	The probability of edges within and between groups/blocks
directed	Should the resulting graph be directed
loops	Are loop edges allowed
rho	The fraction of vertices per cluster
n_islands	The number of densely connected islands
size_islands	The number of nodes in each island
m_between	The number of edges between groups/islands
n_dim, dim_size	The dimension and size of the starting lattice
order	The neighborhood size to create connections from
p_rewire	The rewiring probability of edges
multiple	Are multiple edges allowed

Value

A `tbl_graph` object

Functions

- `play_blocks`: Create graphs by sampling from stochastic block model. See `igraph::sample_sbm()`
- `play_blocks_hierarchy`: Create graphs by sampling from the hierarchical stochastic block model. See `igraph::sample_hierarchical_sbm()`
- `play_islands`: Create graphs with fixed size and edge probability of subgraphs as well as fixed edge count between subgraphs. See `igraph::sample_islands()`
- `play_smallworld`: Create graphs based on the Watts-Strogatz small-world model. See `igraph::sample_smallworld()`

See Also

Other graph games: [evolution_games](#), [sampling_games](#), [type_games](#)

Examples

```
plot(play_islands(4, 10, 0.7, 3))
```

context_accessors

Access graph, nodes, and edges directly inside verbs

Description

These three functions makes it possible to directly access either the node data, the edge data or the graph itself while computing inside verbs. It is e.g. possible to add an attribute from the node data to the edges based on the terminating nodes of the edge, or extract some statistics from the graph itself to use in computations.

Usage

```
.G()
```

```
.N()
```

```
.E()
```

Value

Either a `tbl_graph` (`.G()`) or a tibble (`.N()`)

Functions

- .G: Get the tbl_graph you're currently working on
- .N: Get the nodes data from the graph you're currently working on
- .E: Get the edges data from the graph you're currently working on

Examples

```
# Get data from the nodes while computing for the edges
create_notable('bull') %>%
  activate(nodes) %>%
  mutate(centrality = centrality_power()) %>%
  activate(edges) %>%
  mutate(mean_centrality = (.N()$centrality[from] + .N()$centrality[to])/2)
```

 create_graphs

Create different types of well-defined graphs

Description

These functions creates a long list of different types of well-defined graphs, that is, their structure is not based on any randomisation. All of these functions are shallow wrappers around a range of `igraph::make_*` functions but returns `tbl_graph` rather than `igraph` objects.

Usage

```
create_ring(n, directed = FALSE, mutual = FALSE)

create_path(n, directed = FALSE, mutual = FALSE)

create_chordal_ring(n, w)

create_de_bruijn(alphabet_size, label_size)

create_empty(n, directed = FALSE)

create_bipartite(n1, n2, directed = FALSE, mode = "out")

create_citation(n)

create_complete(n)

create_notable(name)

create_kautz(alphabet_size, label_size)
```

```
create_lattice(dim, directed = FALSE, mutual = FALSE, circular = FALSE)
```

```
create_star(n, directed = FALSE, mutual = FALSE, mode = "out")
```

```
create_tree(n, children, directed = TRUE, mode = "out")
```

Arguments

n, n1, n2	The number of nodes in the graph
directed	Should the graph be directed
mutual	Should mutual edges be created in case of the graph being directed
w	A matrix specifying the additional edges in the chordan ring. See igraph::make_chordal_ring()
alphabet_size	The number of unique letters in the alphabet used for the graph
label_size	The number of characters in each node
mode	In case of a directed, non-mutual, graph should the edges flow 'out' or 'in'
name	The name of a notable graph. See a complete list in igraph::make_graph()
dim	The dimensions of the lattice
circular	Should each dimension in the lattice wrap around
children	The number of children each node has in the tree (if possible)

Value

A `tbl_graph`

Functions

- `create_ring`: Create a simple ring graph
- `create_path`: Create a simple path
- `create_chordal_ring`: Create a chordal ring
- `create_de_bruijn`: Create a de Bruijn graph with the specified alphabet and label size
- `create_empty`: Create a graph with no edges
- `create_bipartite`: Create a full bipartite graph
- `create_citation`: Create a full citation graph
- `create_complete`: Create a complete graph (a graph where all nodes are connected)
- `create_notable`: Create a graph based on its name. See [igraph::make_graph\(\)](#)
- `create_kautz`: Create a Kautz graph with the specified alphabet and label size
- `create_lattice`: Create a multidimensional grid of nodes
- `create_star`: Create a star graph (A single node in the center connected to all other nodes)
- `create_tree`: Create a tree graph

Examples

```
# Create a complete graph with 10 nodes
create_complete(10)
```

Description

These functions lets the user query whether the edges in a graph is of a specific type. All functions return a logical vector giving whether each edge in the graph corresponds to the specific type.

Usage

```
edge_is_multiple()
```

```
edge_is_loop()
```

```
edge_is_mutual()
```

Value

A logical vector of the same length as the number of edges in the graph

Functions

- `edge_is_multiple`: Query whether each edge has any parallel siblings
- `edge_is_loop`: Query whether each edge is a loop
- `edge_is_mutual`: Query whether each edge has a sibling going in the reverse direction

Examples

```
create_star(10, directed = TRUE, mutual = TRUE) %>%  
  activate(edges) %>%  
  sample_frac(0.7) %>%  
  mutate(single_edge = !edge_is_mutual())
```

Description

This games create graphs through different types of evolutionary mechanisms (not necessarily in a biological sense). The nature of their algorithm is described in detail at the linked [igraph documentation](#).

Usage

```

play_citation_age(n, growth = 1, bins = n/7100, p_pref = (1:(bins +
1))^-3, directed = TRUE)

play_forestfire(n, p_forward, p_backward = p_forward, growth = 1,
directed = TRUE)

play_growing(n, growth = 1, directed = TRUE, citation = FALSE)

play_barabasi_albert(n, power, growth = 1, growth_dist = NULL,
use_out = FALSE, appeal_zero = 1, directed = TRUE,
method = "psumtree")

play_barabasi_albert_aging(n, power, power_age, growth = 1,
growth_dist = NULL, bins = 300, use_out = FALSE, appeal_zero = 1,
appeal_zero_age = 0, directed = TRUE, coefficient = 1,
coefficient_age = 1, window = NULL)

```

Arguments

n	The number of nodes in the graph.
growth	The number of edges added at each iteration
bins	The number of aging bins
p_pref	The probability that an edge will be made to an age bin.
directed	Should the resulting graph be directed
p_forward, p_backward	Forward and backward burning probability
citation	Should a citation graph be created
power	The power of the preferential attachment
growth_dist	The distribution of the number of added edges at each iteration
use_out	Should outbound edges be used for calculating citation probability
appeal_zero	The appeal value for unconnected nodes
method	The algorithm to use for graph creation. Either 'psumtree', 'psumtree-multiple', or 'bag'
power_age	The aging exponent
appeal_zero_age	The appeal value of nodes without age
coefficient	The coefficient of the degree dependent part of attractiveness
coefficient_age	The coefficient of the age dependent part of attractiveness
window	The aging window to take into account when calculating the preferential attraction

Value

A `tbl_graph` object

Functions

- `play_citation_age`: Create citation graphs based on a specific age link probability. See [igraph::sample_last_cit\(\)](#)
- `play_forestfire`: Create graphs by simulating the spread of fire in a forest. See [igraph::sample_forestfire\(\)](#)
- `play_growing`: Create graphs by adding a fixed number of edges at each iteration. See [igraph::sample_growing\(\)](#)
- `play_barabasi_albert`: Create graphs based on the Barabasi-Alberts preferential attachment model. See [igraph::sample_pa\(\)](#)
- `play_barabasi_albert_aging`: Create graphs based on the Barabasi-Alberts preferential attachment model, incorporating node age preference. See [igraph::sample_pa_age\(\)](#).

See Also

[play_traits\(\)](#) and [play_citation_type\(\)](#) for an evolutionary algorithm based on different node types

Other graph games: [component_games](#), [sampling_games](#), [type_games](#)

Examples

```
plot(play_forestfire(50, 0.5))
```

graph_join

Join graphs on common nodes

Description

This graph-specific join method makes a full join on the nodes data and updates the edges in the joining graph so they matches the new indexes of the nodes in the resulting graph. Node and edge data is combined using [dplyr::bind_rows\(\)](#) semantic, meaning that data is matched by column name and filled with NA if it is missing in either of the graphs.

Usage

```
graph_join(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)
```

Arguments

x	A <code>tbl_graph</code>
y	An object convertible to a <code>tbl_graph</code> using <code>as_tbl_graph()</code>
by	a character vector of variables to join by. If NULL, the default, <code>*_join()</code> will do a natural join, using all variables with common names across the two tables. A message lists the variables so that you can check they're right (to suppress the message, simply explicitly list the variables that you want to join). To join by different variables on x and y use a named vector. For example, <code>by = c("a" = "b")</code> will match x.a to y.b.
copy	If x and y are not from the same data source, and copy is TRUE, then y will be copied into the same src as x. This allows you to join tables across srcs, but it is a potentially expensive operation so you must opt into it.
suffix	If there are non-joined duplicate variables in x and y, these suffixes will be added to the output to diambiguate them. Should be a character vector of length 2.
...	other parameters passed onto methods

Value

A `tbl_graph` containing the merged graph

Examples

```
gr1 <- create_notable('bull') %>%
  activate(nodes) %>%
  mutate(name = letters[1:5])
gr2 <- create_ring(10) %>%
  activate(nodes) %>%
  mutate(name = letters[4:13])

gr1 %>% graph_join(gr2)
```

graph_measures

Graph measurements

Description

This set of functions provide wrappers to a number of `igraphs` graph statistic algorithms. As for the other wrappers provided, they are intended for use inside the `tidygraph` framework and it is thus not necessary to supply the graph being computed on as the context is known. All of these functions are guaranteed to return scalars making it easy to compute with them.

Usage

```
graph_adhesion()

graph_assortativity(attr, in_attr = NULL, directed = TRUE)

graph_automorphisms(sh = "fm")

graph_clique_num()

graph_clique_count(min = NULL, max = NULL, subset = NULL)

graph_component_count(type = "weak")

graph_motif_count(size = 3, cut.prob = rep(0, size))

graph_diameter(weights = NULL, directed = TRUE, unconnected = TRUE)

graph_girth()

graph_radius(mode = "out")

graph_mutual_count()

graph_asym_count()

graph_unconn_count()

graph_size()

graph_order()

graph_reciprocity(ignore_loops = TRUE, ratio = FALSE)

graph_min_cut(capacity = NULL)

graph_mean_dist(directed = TRUE, unconnected = TRUE)
```

Arguments

attr	The node attribute to measure on
in_attr	An alternative node attribute to use for incoming node. If NULL the attribute given by type will be used
directed	Should a directed graph be treated as directed
sh	The splitting heuristics for the BLISS algorithm. Possible values are: 'f': first non-singleton cell, 'f1': first largest non-singleton cell, 'fs': first smallest non-singleton cell, 'fm': first maximally non-trivially connected non-singleton cell, 'f1m': first largest maximally non-trivially connected non-singleton cell, 'fsm': first smallest maximally non-trivially connected non-singleton cell.

min, max	The upper and lower bounds of the cliques to be considered.
subset	The indexes of the nodes to start the search from (logical or integer). If provided only the cliques containing these nodes will be counted.
type	The type of component to count, either 'weak' or 'strong'. Ignored for undirected graphs.
size	The size of the motif, currently 3 and 4 are supported only.
cut.prob	Numeric vector giving the probabilities that the search graph is cut at a certain level. Its length should be the same as the size of the motif (the size argument). By default no cuts are made.
weights	Optional positive weight vector for calculating weighted distances. If the graph has a weight edge attribute, then this is used by default.
unconnected	Logical, what to do if the graph is unconnected. If FALSE, the function will return a number that is one larger the largest possible diameter, which is always the number of vertices. If TRUE, the diameters of the connected components will be calculated and the largest one will be returned.
mode	How should eccentricity be calculated. If "out" only outbound edges are followed. If "in" only inbound are followed. If "all" all edges are followed. Ignored for undirected graphs.
ignore_loops	Logical. Should loops be ignored while calculating the reciprocity
ratio	Should the old "ratio" approach from igraph < v0.6 be used
capacity	The capacity of the edges

Value

A scalar, the type depending on the function

Functions

- graph_adhesion: Gives the minimum edge connectivity. Wraps `igraph::edge_connectivity()`
- graph_assortativity: Measures the propensity of similar nodes to be connected. Wraps `igraph::assortativity()`
- graph_automorphisms: Calculate the number of automorphisms of the graph. Wraps `igraph::automorphisms()`
- graph_clique_num: Get the size of the largest clique. Wraps `igraph::clique_num()`
- graph_clique_count: Get the number of maximal cliques in the graph. Wraps `igraph::count_max_cliques()`
- graph_component_count: Count the number of unconnected componenets in the graph. Wraps `igraph::count_components()`
- graph_motif_count: Count the number of motifs in a graph. Wraps `igraph::count_motifs()`
- graph_diameter: Measures the length of the longest geodesic. Wraps `igraph::diameter()`
- graph_girth: Measrues the length of the shortest circle in the graph. Wraps `igraph::girth()`
- graph_radius: Measures the smallest eccentricity in the graph. Wraps `igraph::radius()`
- graph_mutual_count: Counts the number of mutually connected nodes. Wraps `igraph::dyad_census()`
- graph_asym_count: Counts the number of asymmetrically connected nodes. Wraps `igraph::dyad_census()`

- `graph_unconn_count`: Counts the number of unconnected node pairs. Wraps `igraph::dyad_census()`
- `graph_size`: Counts the number of edges in the graph. Wraps `igraph::gsize()`
- `graph_order`: Counts the number of nodes in the graph. Wraps `igraph::gorder()`
- `graph_reciprocity`: Measures the proportion of mutual connections in the graph. Wraps `igraph::reciprocity()`
- `graph_min_cut`: Calculates the minimum number of edges to remove in order to split the graph into two clusters. Wraps `igraph::min_cut()`
- `graph_mean_dist`: Calculates the mean distance between all node pairs in the graph. Wraps `igraph::mean_distance()`

Examples

```
# Use e.g. to modify computations on nodes and edges
create_notable('meredith') %>%
  activate(nodes) %>%
  mutate(rel_neighbors = centrality_degree()/graph_order())
```

group_graph

Group nodes and edges based on community structure

Description

These functions are wrappers around the various clustering functions provided by igraph. As with the other wrappers they automatically use the graph that is being computed on, and otherwise passes on its arguments to the relevant clustering function. The return value is always a numeric vector of group memberships so that nodes or edges with the same number are part of the same group. Grouping is predominantly made on nodes and currently the only grouping of edges supported is biconnected components.

Usage

```
group_components(type = "weak")

group_edge_betweenness(weights = NULL, directed = TRUE)

group_fast_greedy(weights = NULL)

group_infomap(weights = NULL, node_weights = NULL, trials = 10)

group_label_prop(weights = NULL, label = NULL, fixed = NULL)

group_leading_eigen(weights = NULL, steps = -1, label = NULL,
  options = igraph::arpack_defaults)

group_louvain(weights = NULL)
```

```
group_optimal(weights = NULL)
group_spinglass(weights = NULL, ...)
group_walktrap(weights = NULL, steps = 4)
group_biconnected_component()
```

Arguments

type	The type of component to find. Either 'weak' or 'strong'
weights	The weight of the edges to use for the calculation. Will be evaluated in the context of the edge data.
directed	Should direction of edges be used for the calculations
node_weights	The weight of the nodes to use for the calculation. Will be evaluated in the context of the node data.
trials	Number of times partition of the network should be attempted
label	The initial groups of the nodes. Will be evaluated in the context of the node data.
fixed	A logical vector determining which nodes should keep their initial groups. Will be evaluated in the context of the node data.
steps	The number of steps in the random walks
options	Settings passed on to <code>igraph::arpack()</code>
...	arguments passed on to <code>igraph::cluster_spinglass()</code>

Value

a numeric vector with the membership for each node in the graph

Functions

- `group_components`: Group by connected components using `igraph::components()`
- `group_edge_betweenness`: Group densely connected nodes using `igraph::cluster_edge_betweenness()`
- `group_fast_greedy`: Group nodes by optimising modularity using `igraph::cluster_fast_greedy()`
- `group_infomap`: Group nodes by minimizing description length using `igraph::cluster_infomap()`
- `group_label_prop`: Group nodes by propagating labels using `igraph::cluster_label_prop()`
- `group_leading_eigen`: Group nodes based on the leading eigenvector of the modularity matrix using `igraph::cluster_leading_eigen()`
- `group_louvain`: Group nodes by multilevel optimisation of modularity using `igraph::cluster_louvain()`
- `group_optimal`: Group nodes by optimising the modularity score using `igraph::cluster_optimal()`
- `group_spinglass`: Group nodes using simulated annealing with `igraph::cluster_spinglass()`
- `group_walktrap`: Group nodes via short random walks using `igraph::cluster_walktrap()`
- `group_biconnected_component`: Group edges by their membership of the maximal biconnected components using `igraph::biconnected_components()`

Examples

```
create_notable('tutte') %>%
  activate(nodes) %>%
  mutate(group = group_infomap())
```

local_graph	<i>Measures based on the neighborhood of each node</i>
-------------	--

Description

These functions wraps a set of functions that all measures quantities of the local neighborhood of each node. They all return a vector or list matching the node position.

Usage

```
local_size(order = 1, mode = "all", mindist = 0)

local_members(order = 1, mode = "all", mindist = 0)

local_triangles()

local_ave_degree(weights = NULL)

local_transitivity(weights = NULL)
```

Arguments

order	Integer giving the order of the neighborhood.
mode	Character constant, it specifies how to use the direction of the edges if a directed graph is analyzed. For 'out' only the outgoing edges are followed, so all vertices reachable from the source vertex in at most order steps are counted. For "in" all vertices from which the source vertex is reachable in at most order steps are counted. "all" ignores the direction of the edges. This argument is ignored for undirected graphs.
mindist	The minimum distance to include the vertex in the result.
weights	Weight vector. If the graph has a weight edge attribute, then this is used by default. If this argument is given, then vertex strength (see strength) is used instead of vertex degree. But note that knnk is still given in the function of the normal vertex degree.

Value

A numeric vector or a list (for local_members) with elements corresponding to the nodes in the graph.

Functions

- `local_size`: The size of the neighborhood in a given distance from the node. (Note that the node itself is included unless `mindist > 0`). Wraps `igraph::ego_size()`.
- `local_members`: The members of the neighborhood of each node in a given distance. Wraps `igraph::ego()`.
- `local_triangles`: The number of triangles each node participate in. Wraps `igraph::count_triangles()`.
- `local_ave_degree`: Calculates the average degree based on the neighborhood of each node. Wraps `igraph::knn()`.
- `local_transitivity`: Calculate the transitivity of each node, that is, the propensity for the nodes neighbors to be connected. Wraps `igraph::transitivity()`

Examples

```
# Get all neighbors of each graph
create_notable('chvatal') %>%
  activate(nodes) %>%
  mutate(neighborhood = local_members(mindist = 1))

# These are equivalent
create_notable('chvatal') %>%
  activate(nodes) %>%
  mutate(n_neighbors = local_size(mindist = 1),
         degree = centrality_degree()) %>%
  as_tibble()
```

map_bfs

Apply a function to nodes in the order of a breath first search

Description

These functions allow you to map over the nodes in a graph, by first performing a breath first search on the graph and then mapping over each node in the order they are visited. The mapping function will have access to the result and search statistics for all the nodes between itself and the root in the search. To map over the nodes in the reverse direction use `map_bfs_back()`.

Usage

```
map_bfs(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_bfs_lgl(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_bfs_chr(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_bfs_int(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_bfs_dbl(root, mode = "out", unreachable = FALSE, .f, ...)
```

Arguments

root	The node to start the search from
mode	How should edges be followed? 'out' only follows outbound edges, 'in' only follows inbound edges, and 'all' follows all edges. This parameter is ignored for undirected graphs.
unreachable	Should the search jump to an unvisited node if the search is completed without visiting all nodes.
.f	A function to map over all nodes. See Details
...	Additional parameters to pass to .f

Details

The function provided to .f will be called with the following arguments in addition to those supplied through ...:

- graph: The full tbl_graph object
- node: The index of the node currently mapped over
- rank: The rank of the node in the search
- parent: The index of the node that led to the current node
- before: The index of the node that was visited before the current node
- after: The index of the node that was visited after the current node.
- dist: The distance of the current node from the root
- path: A table containing node, rank, parent, before, after, dist, and result columns giving the values for each node leading to the current node. The result column will contain the result of the mapping of each node in a list.

Instead of spelling out all of these in the function it is possible to simply name the ones needed and use ... to catch the rest.

Value

map_bfs() returns a list of the same length as the number of nodes in the graph, in the order matching the node order in the graph (that is, not in the order they are called). map_bfs_*() tries to coerce its result into a vector of the classes logical (map_bfs_lgl), character (map_bfs_chr), integer (map_bfs_int), or double (map_bfs_dbl). These functions will throw an error if they are unsuccessful, so they are type safe.

See Also

Other node map functions: [map_bfs_back](#), [map_dfs_back](#), [map_dfs](#)

Examples

```
# Accumulate values along a search
create_tree(40, children = 3, directed = TRUE) %>%
  mutate(value = round(runif(40)*100)) %>%
  mutate(value_acc = map_bfs_dbl(node_is_root(), .f = function(node, path, ...) {
    sum(.N())$value[c(node, path$node)])
  })))
```

map_bfs_back

Apply a function to nodes in the reverse order of a breath first search

Description

These functions allow you to map over the nodes in a graph, by first performing a breath first search on the graph and then mapping over each node in the reverse order they are visited. The mapping function will have access to the result and search statistics for all the nodes following itself in the search. To map over the nodes in the original direction use [map_bfs\(\)](#).

Usage

```
map_bfs_back(root, mode = "out", unreachable = FALSE, .f, ...)
map_bfs_back_lgl(root, mode = "out", unreachable = FALSE, .f, ...)
map_bfs_back_chr(root, mode = "out", unreachable = FALSE, .f, ...)
map_bfs_back_int(root, mode = "out", unreachable = FALSE, .f, ...)
map_bfs_back_dbl(root, mode = "out", unreachable = FALSE, .f, ...)
```

Arguments

root	The node to start the search from
mode	How should edges be followed? 'out' only follows outbound edges, 'in' only follows inbound edges, and 'all' follows all edges. This parameter is ignored for undirected graphs.
unreachable	Should the search jump to an unvisited node if the search is completed without visiting all nodes.
.f	A function to map over all nodes. See Details
...	Additional parameters to pass to .f

Details

The function provided to `.f` will be called with the following arguments in addition to those supplied through `...`:

- `graph`: The full `tbl_graph` object
- `node`: The index of the node currently mapped over
- `rank`: The rank of the node in the search
- `parent`: The index of the node that led to the current node
- `before`: The index of the node that was visited before the current node
- `after`: The index of the node that was visited after the current node.
- `dist`: The distance of the current node from the root
- `path`: A table containing `node`, `rank`, `parent`, `before`, `after`, `dist`, and `result` columns giving the values for each node reached from the current node. The `result` column will contain the result of the mapping of each node in a list.

Instead of spelling out all of these in the function it is possible to simply name the ones needed and use `...` to catch the rest.

Value

`map_bfs_back()` returns a list of the same length as the number of nodes in the graph, in the order matching the node order in the graph (that is, not in the order they are called). `map_bfs_back_*` tries to coerce its result into a vector of the classes `logical` (`map_bfs_back_lgl`), `character` (`map_bfs_back_chr`), `integer` (`map_bfs_back_int`), or `double` (`map_bfs_back_dbl`). These functions will throw an error if they are unsuccessful, so they are type safe.

See Also

Other node map functions: [map_bfs](#), [map_dfs_back](#), [map_dfs](#)

Examples

```
# Collect values from children
create_tree(40, children = 3, directed = TRUE) %>%
  mutate(value = round(runif(40)*100)) %>%
  mutate(child_acc = map_bfs_back_dbl(node_is_root(), .f = function(node, path, ...) {
    if (nrow(path) == 0) .N()$value[node]
    else {
      sum(unlist(path$result[path$parent == node]))
    }
  })
  )))
```

map_dfs

*Apply a function to nodes in the order of a depth first search***Description**

These functions allow you to map over the nodes in a graph, by first performing a depth first search on the graph and then mapping over each node in the order they are visited. The mapping function will have access to the result and search statistics for all the nodes between itself and the root in the search. To map over the nodes in the reverse direction use [map_dfs_back\(\)](#).

Usage

```
map_dfs(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_lgl(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_chr(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_int(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_dbl(root, mode = "out", unreachable = FALSE, .f, ...)
```

Arguments

root	The node to start the search from
mode	How should edges be followed? 'out' only follows outbound edges, 'in' only follows inbound edges, and 'all' follows all edges. This parameter is ignored for undirected graphs.
unreachable	Should the search jump to an unvisited node if the search is completed without visiting all nodes.
.f	A function to map over all nodes. See Details
...	Additional parameters to pass to .f

Details

The function provided to .f will be called with the following arguments in addition to those supplied through ...:

- graph: The full tbl_graph object
- node: The index of the node currently mapped over
- rank: The rank of the node in the search
- rank_out: The rank of the completion of the nodes subtree
- parent: The index of the node that led to the current node
- dist: The distance of the current node from the root

- path: A table containing node, rank, rank_out, parent, dist, and result columns giving the values for each node. The result column will contain the result of the mapping of each node in a list.

Instead of spelling out all of these in the function it is possible to simply name the ones needed and use ... to catch the rest.

Value

map_dfs() returns a list of the same length as the number of nodes in the graph, in the order matching the node order in the graph (that is, not in the order they are called). map_dfs_*() tries to coerce its result into a vector of the classes logical (map_dfs_lgl), character (map_dfs_chr), integer (map_dfs_int), or double (map_dfs_dbl). These functions will throw an error if they are unsuccessful, so they are type safe.

See Also

Other node map functions: [map_bfs_back](#), [map_bfs](#), [map_dfs_back](#)

Examples

```
# Add a random integer to the last value along a search
create_tree(40, children = 3, directed = TRUE) %>%
  mutate(child_acc = map_dfs_int(node_is_root(), .f = function(node, path, ...) {
    last_val <- if (nrow(path) == 0) 0L else tail(unlist(path$result), 1)
    last_val + sample(1:10, 1)
  })))
```

map_dfs_back

Apply a function to nodes in the reverse order of a depth first search

Description

These functions allow you to map over the nodes in a graph, by first performing a depth first search on the graph and then mapping over each node in the reverse order they are visited. The mapping function will have access to the result and search statistics for all the nodes following itself in the search. To map over the nodes in the original direction use [map_dfs\(\)](#).

Usage

```
map_dfs_back(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_back_lgl(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_back_chr(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_back_int(root, mode = "out", unreachable = FALSE, .f, ...)
```

```
map_dfs_back_dbl(root, mode = "out", unreachable = FALSE, .f, ...)
```

Arguments

root	The node to start the search from
mode	How should edges be followed? 'out' only follows outbound edges, 'in' only follows inbound edges, and 'all' follows all edges. This parameter is ignored for undirected graphs.
unreachable	Should the search jump to an unvisited node if the search is completed without visiting all nodes.
.f	A function to map over all nodes. See Details
...	Additional parameters to pass to .f

Details

The function provided to .f will be called with the following arguments in addition to those supplied through ...:

- graph: The full tbl_graph object
- node: The index of the node currently mapped over
- rank: The rank of the node in the search
- rank_out: The rank of the completion of the nodes subtree
- parent: The index of the node that led to the current node
- dist: The distance of the current node from the root
- path: A table containing node, rank, rank_out, parent, dist, and result columns giving the values for each node. The result column will contain the result of the mapping of each node in a list.

Instead of spelling out all of these in the function it is possible to simply name the ones needed and use ... to catch the rest.

Value

map_dfs_back() returns a list of the same length as the number of nodes in the graph, in the order matching the node order in the graph (that is, not in the order they are called). map_dfs_back_*() tries to coerce its result into a vector of the classes logical (map_dfs_back_lgl), character (map_dfs_back_chr), integer (map_dfs_back_int), or double (map_dfs_back_dbl). These functions will throw an error if they are unsuccessful, so they are type safe.

See Also

Other node map functions: [map_bfs_back](#), [map_bfs](#), [map_dfs](#)

Examples

```
# Collect values from the 2 closest layers of children in a dfs search
create_tree(40, children = 3, directed = TRUE) %>%
  mutate(value = round(runif(40)*100)) %>%
  mutate(child_acc = map_dfs_back(node_is_root(), .f = function(node, path, dist, ...) {
    if (nrow(path) == 0) .N()$value[node]
    else {
```

```

    unlist(path$result[path$dist - dist <= 2])
  }
}))

```

map_local	<i>Map a function over a graph representing the neighborhood of each node</i>
-----------	---

Description

This function extracts the neighborhood of each node as a graph and maps over each of these neighborhood graphs. Conceptually it is similar to `igraph::local_scan()`, but it borrows the type safe versions available in `map_bfs()` and `map_dfs()`.

Usage

```

map_local(order = 1, mode = "all", mindist = 0, .f, ...)
map_local_lgl(order = 1, mode = "all", mindist = 0, .f, ...)
map_local_chr(order = 1, mode = "all", mindist = 0, .f, ...)
map_local_int(order = 1, mode = "all", mindist = 0, .f, ...)
map_local_dbl(order = 1, mode = "all", mindist = 0, .f, ...)

```

Arguments

order	Integer giving the order of the neighborhood.
mode	Character constant, it specifies how to use the direction of the edges if a directed graph is analyzed. For 'out' only the outgoing edges are followed, so all vertices reachable from the source vertex in at most order steps are counted. For "in" all vertices from which the source vertex is reachable in at most order steps are counted. "all" ignores the direction of the edges. This argument is ignored for undirected graphs.
mindist	The minimum distance to include the vertex in the result.
.f	A function to map over all nodes. See Details
...	Additional parameters to pass to .f

Details

The function provided to `.f` will be called with the following arguments in addition to those supplied through `...`:

- `neighborhood`: The neighborhood graph of the node
- `graph`: The full `tbl_graph` object
- `node`: The index of the node currently mapped over

Value

`map_local()` returns a list of the same length as the number of nodes in the graph, in the order matching the node order in the graph. `map_local_*` tries to coerce its result into a vector of the classes logical (`map_local_lgl`), character (`map_local_chr`), integer (`map_local_int`), or double (`map_local_dbl`). These functions will throw an error if they are unsuccessful, so they are type safe.

Examples

```
# Smooth out values over a neighborhood
create_notable('meredith') %>%
  mutate(value = rpois(graph_order(), 5)) %>%
  mutate(value_smooth = map_local_dbl(order = 2, .f = function(neighborhood, ...) {
    mean(as_tibble(neighborhood, active = 'nodes')$value)
  })))
```

 morph

Create a temporary alternative representation of the graph to compute on

Description

The `morph/unmorph` verbs are used to create temporary representations of the graph, such as e.g. its search tree or a subgraph. A morphed graph will accept any of the standard `dplyr` verbs, and changed to the data is automatically propagated to the original graph when unmorphing. Tidygraph comes with a range of [morphers](#), but it is also possible to supply your own. See [Details](#) for the requirement for custom morphers. The `crystallise` verb is used to extract the temporary graph representation into a tibble containing one separate graph per row and a name and graph column holding the name of each graph and the graph itself respectively.

Usage

```
morph(.data, .f, ...)
```

```
unmorph(.data)
```

```
crystallise(.data)
```

```
crystallize(.data)
```

Arguments

`.data` A `tbl_graph` or a `morphed_tbl_graph`

`.f` A morphing function. See [morphers](#) for a list of provided one.

`...` Arguments passed on to the morpher

Details

It is only possible to change and add to node and edge data from a morphed state. Any filtering/removal of nodes and edges will not result in removal from the main graph. However, nodes and edges not present in the morphed state will be unaffected in the main graph when unmorphing (if new columns were added during the morphed state they will be filled with NA).

Morphing an already morphed graph will unmorph prior to applying the new morph.

During a morphed state, the mapping back to the original graph is stored in `.tidygraph_node_index` and `.tidygraph_edge_index` columns. These are accessible but protected, meaning that any changes to them with e.g. `mutate` will be ignored. Furthermore, if the morph results in the merging of nodes and/or edges the original data is stored in a `.data` column. This is protected as well.

When supplying your own morphers the morphing function should accept a `tbl_graph` as its first input. The provided graph will already have nodes and edges mapped with a `.tidygraph_node_index` and `.tidygraph_edge_index` column. The return value must be a `tbl_graph` or a list of `tbl_graphs` and these must contain either a `.tidygraph_node_index` column or a `.tidygraph_edge_index` column (or both). Note that it is possible for the morph to have the edges mapped back to the original nodes and vice versa (e.g. as with [to_linegraph](#)). In that case the edge data in the morphed graph(s) will contain a `.tidygraph_node_index` column and or the node data a `.tidygraph_edge_index` column. If the morphing results in the collapse of multiple columns or edges the index columns should be converted to list columns mapping the new node/edge back to all the nodes/edges it represents. Furthermore the original node/edge data should be collapsed to a list of tibbles, with the row order matching the order in the index column element.

Value

A `morphed_tbl_graph`

Examples

```
create_notable('meredith') %>%
  mutate(group = group_infomap()) %>%
  morph(to_contracted, group) %>%
  mutate(group_centrality = centrality_pagerank()) %>%
  unmorph()
```

morphers

Functions to generate alternate representations of graphs

Description

These functions are meant to be passed into `morph()` to create a temporary alternate representation of the input graph. They are thus not meant to be called directly. See below for detail of each morpher.

Usage

```

to_linegraph(graph)

to_subgraph(graph, ..., subset_by = NULL)

to_split(graph, ..., split_by = NULL)

to_components(graph, type = "weak")

to_complement(graph, loops = FALSE)

to_local_neighborhood(graph, node, order = 1, mode = "all")

to_dominator_tree(graph, root, mode = "out")

to_minimum_spanning_tree(graph, weights = NULL)

to_shortest_path(graph, from, to, mode = "out", weights = NULL)

to_bfs_tree(graph, root, mode = "out", unreachable = FALSE)

to_dfs_tree(graph, root, mode = "out", unreachable = FALSE)

to_simple(graph)

to_contracted(graph, ..., simplify = TRUE)

```

Arguments

graph	A <code>tbl_graph</code>
...	Arguments to pass on to <code>filter()</code> or <code>group_by()</code>
subset_by, split_by	Whether to create subgraphs based on nodes or edges
type	The type of component to split into. Either 'weak' or 'strong'
loops	Should loops be included. Defaults to FALSE
node	The center of the neighborhood
order	The radius of the neighborhood
mode	How should edges be followed? 'out' only follows outbound edges, 'in' only follows inbound edges, and 'all' follows all edges. This parameter is ignored for undirected graphs.
root	The root of the tree
weights	Optional edge weights for the calculations
from, to	The start and end node of the path
unreachable	Should the search jump to a node in a new component when stuck.
simplify	Should edges in the contracted graph be simplified? Defaults to TRUE

Value

A list of tbl_graphs

Functions

- `to_linegraph`: Convert a graph to its line graph. When unmorphing node data will be merged back into the original edge data. Edge data will be ignored.
- `to_subgraph`: Convert a graph to a single subgraph. `...` is evaluated in the same manner as `filter`. When unmorphing all data in the subgraph will get merged back.
- `to_split`: Convert a graph into a list of separate subgraphs. `...` is evaluated in the same manner as `group_by`. When unmorphing all data in the subgraphs will get merged back, but in the case of `split_by = 'edges'` only the first instance of node data will be used (as the same node can be present in multiple subgraphs).
- `to_components`: Split a graph into its separate components. When unmorphing all data in the subgraphs will get merged back.
- `to_complement`: Convert a graph into its complement. When unmorphing only node data will get merged back.
- `to_local_neighborhood`: Convert a graph into the local neighborhood around a single node. When unmorphing all data will be merged back.
- `to_dominator_tree`: Convert a graph into its dominator tree based on a specific root. When unmorphing only node data will get merged back.
- `to_minimum_spanning_tree`: Convert a graph into its minimum spanning tree/forest. When unmorphing all data will get merged back.
- `to_shortest_path`: Limit a graph to the shortest path between two nodes. When unmorphing all data is merged back.
- `to_bfs_tree`: Convert a graph into a breath-first search tree based on a specific root. When unmorphing only node data is merged back.
- `to_dfs_tree`: Convert a graph into a depth-first search tree based on a specific root. When unmorphing only node data is merged back.
- `to_simple`: Collapse parallel edges and remove loops in a graph. When unmorphing all data will get merged back.
- `to_contracted`: Combine multiple nodes into one. `...` is evaluated in the same manner as `group_by`. When unmorphing all data will get merged back.

Examples

```
# Compute only on a subgraph of every even node
create_notable('meredith') %>%
  morph(to_subgraph, seq_len(graph_order()) %% 2 == 0) %>%
  mutate(neighbour_count = centrality_degree()) %>%
  unmorph()
```

node_measures

Querying node measures

Description

These functions are a collection of node measures that do not really fall into the class of [centrality](#) measures. For lack of a better place they are collected under the `node_*` umbrella of functions.

Usage

```
node_eccentricity(mode = "out")
node_constraint(weights = NULL)
node_coreness(mode = "out")
node_diversity(weights = NULL)
```

Arguments

<code>mode</code>	The way edges should be followed in the case of directed graphs.
<code>weights</code>	The weights to use for each node during calculation

Value

A numeric vector of the same length as the number of nodes in the graph.

Functions

- `node_eccentricity`: measure the maximum shortest path to all other nodes in the graph
- `node_constraint`: measures Burt's constraint of the node. See [igraph::constraint\(\)](#)
- `node_coreness`: measures the coreness of each node. See [igraph::coreness\(\)](#)
- `node_diversity`: measures the diversity of the node. See [igraph::diversity\(\)](#)

Examples

```
# Calculate Burt's Constraint for each node
create_notable('meredith') %>%
  mutate(b_constraint = node_constraint())
```

node_topology	<i>Node properties related to the graph topology</i>
---------------	--

Description

These functions calculate properties that are dependent on the overall topology of the graph.

Usage

```
node_dominator(root, mode = "out")
```

```
node_topo_order(mode = "out")
```

Arguments

root	The node to start the dominator search from
mode	How should edges be followed. Either 'in' or 'out'

Value

A vector of the same length as the number of nodes in the graph

Functions

- `node_dominator`: Get the immediate dominator of each node. Wraps `igraph::dominator_tree()`.
- `node_topo_order`: Get the topological order of nodes in a DAG. Wraps `igraph::topo_sort()`.

Examples

```
# Sort a graph based on its topological order
create_tree(10, 2) %>%
  arrange(sample(graph_order())) %>%
  mutate(old_ind = seq_len(graph_order())) %>%
  arrange(node_topo_order())
```

node_types	<i>Querying node types</i>
------------	----------------------------

Description

These functions all lets the user query whether each node is of a certain type. All of the functions returns a logical vector indicating whether the node is of the type in question. Do note that the types are not mutually exclusive and that nodes can thus be of multiple types.

Usage

```
node_is_cut()

node_is_root()

node_is_leaf()

node_is_sink()

node_is_source()

node_is_isolated()

node_is_universal(mode = "out")

node_is_simplicial(mode = "out")

node_is_center(mode = "out")
```

Arguments

mode The way edges should be followed in the case of directed graphs.

Value

A logical vector of the same length as the number of nodes in the graph.

Functions

- `node_is_cut`: is the node a cut node (articulation node)
- `node_is_root`: is the node a root in a tree
- `node_is_leaf`: is the node a leaf in a tree
- `node_is_sink`: does the node only have incoming edges
- `node_is_source`: does the node only have outgoing edges
- `node_is_isolated`: is the node unconnected
- `node_is_universal`: is the node connected to all other nodes in the graph
- `node_is_simplicial`: are all the neighbors of the node connected
- `node_is_center`: does the node have the minimal eccentricity in the graph

Examples

```
# Find the root and leafs in a tree
create_tree(40, 2) %>%
  mutate(root = node_is_root(), leaf = node_is_leaf())
```

pair_measures	<i>Calculate node pair properties</i>
---------------	---------------------------------------

Description

This set of functions can be used for calculations that involve node pairs. If the calculateable measure is not symmetric the function will come in two flavours, differentiated with `_to/_from` suffix. The `*_to()` functions will take the provided node indexes as the target node (recycling if necessary). For the `*_from()` functions the provided nodes are taken as the source. As for the other wrappers provided, they are intended for use inside the `tidygraph` framework and it is thus not necessary to supply the graph being computed on as the context is known.

Usage

```
node_adhesion_to(nodes)
```

```
node_adhesion_from(nodes)
```

```
node_cohesion_to(nodes)
```

```
node_cohesion_from(nodes)
```

```
node_distance_to(nodes, mode = "out", weights = NA,  
  algorithm = "automatic")
```

```
node_distance_from(nodes, mode = "out", weights = NA,  
  algorithm = "automatic")
```

```
node_cocitation_with(nodes)
```

```
node_bibcoupling_with(nodes)
```

```
node_similarity_with(nodes, mode = "out", loops = FALSE,  
  method = "jaccard")
```

```
node_max_flow_to(nodes, capacity = NULL)
```

```
node_max_flow_from(nodes, capacity = NULL)
```

Arguments

nodes	The other part of the node pair (the first part is the node defined by the row). Recycled if necessary.
mode	How should edges be followed? If 'all' all edges are considered, if 'in' only inbound edges are considered, and if 'out' only outbound edges are considered
weights	The weights to use for calculation

algorithm	The distance algorithms to use. By default it will try to select the fastest suitable algorithm. Possible values are "automatic", "unweighted", "dijkstra", "bellman-ford", and "johnson"
loops	Should loop edges be considered
method	The similarity measure to calculate. Possible values are: "jaccard", "dice", and "invlogweighted"
capacity	The edge capacity to use

Value

A numeric vector of the same length as the number of nodes in the graph

Functions

- `node_adhesion_to`: Calculate the adhesion to the specified node. Wraps `igraph::edge_connectivity()`
- `node_adhesion_from`: Calculate the adhesion from the specified node. Wraps `igraph::edge_connectivity()`
- `node_cohesion_to`: Calculate the cohesion to the specified node. Wraps `igraph::vertex_connectivity()`
- `node_cohesion_from`: Calculate the cohesion from the specified node. Wraps `igraph::vertex_connectivity()`
- `node_distance_to`: Calculate various distance metrics between node pairs. Wraps `igraph::distances()`
- `node_distance_from`: Calculate various distance metrics between node pairs. Wraps `igraph::distances()`
- `node_cocitation_with`: Calculate node pair cocitation count. Wraps `igraph::cocitation()`
- `node_bibcoupling_with`: Calculate node pair bibliographic coupling. Wraps `igraph::bibcoupling()`
- `node_similarity_with`: Calculate various node pair similarity measures. Wraps `igraph::similarity()`
- `node_max_flow_to`: Calculate the maximum flow to a node. Wraps `igraph::max_flow()`
- `node_max_flow_from`: Calculate the maximum flow from a node. Wraps `igraph::max_flow()`

Examples

```
# Calculate the distance to the center node
create_notable('meredith') %>%
  mutate(dist_to_center = node_distance_to(node_is_center()))
```

reroute

Change terminal nodes of edges

Description

The reroute verb lets you change the beginning and end node of edges by specifying the new indexes of the start and/or end node(s). Optionally only a subset of the edges can be rerouted using the subset argument, which should be an expression that are to be evaluated in the context of the edge data and should return an index compliant vector (either logical or integer).

Usage

```
reroute(.data, from = NULL, to = NULL, subset = NULL)
```

Arguments

.data	A <code>tbl_graph</code> or <code>morphed_tbl_graph</code> object. <code>grouped_tbl_graph</code> will be ungrouped prior to rerouting
from, to	The new indexes of the terminal nodes. If <code>NULL</code> nothing will be changed
subset	An expression evaluating to an indexing vector in the context of the edge data.

Value

An object of the same class as `.data`

Examples

```
# Switch direction of edges
create_notable('meredith') %>%
  activate(edges) %>%
  reroute(from = to, to = from)

# Using subset
create_notable('meredith') %>%
  activate(edges) %>%
  reroute(from = 1, subset = to > 10)
```

sampling_games

Graph games based on direct sampling

Description

This set of graph games creates graphs directly through sampling of different attributes, topologies, etc. The nature of their algorithm is described in detail at the linked [igraph](#) documentation.

Usage

```
play_degree(out_degree, in_degree = NULL, method = "simple")

play_dotprod(position, directed = TRUE)

play_fitness(m, out_fit, in_fit = NULL, loops = FALSE, multiple = FALSE)

play_fitness_power(n, m, out_exp, in_exp = -1, loops = FALSE,
  multiple = FALSE, correct = TRUE)

play_erdos_renyi(n, p, m, directed = TRUE, loops = FALSE)

play_geometry(n, radius, torus = FALSE)
```

Arguments

out_degree, in_degree	The degrees of each node in the graph
method	The algorithm to use for the generation. Either 'simple', 'vl', or 'simple.no.multiple'
position	The latent position of each node by column.
directed	Should the resulting graph be directed
m	The number of edges in the graph
out_fit, in_fit	The fitness of each node
loops	Are loop edges allowed
multiple	Are multiple edges allowed
n	The number of nodes in the graph.
out_exp, in_exp	Power law exponent of degree distribution
correct	Use finite size correction
p	The probability of an edge occurring
radius	The radius within which vertices are connected
torus	Should the vertices be distributed on a torus instead of a plane

Value

A `tbl_graph` object

Functions

- `play_degree`: Create graphs based on the given node degrees. See [igraph::sample_degseq\(\)](#)
- `play_dotprod`: Create graphs with link probability given by the dot product of the latent position of terminating nodes. See [igraph::sample_dot_product\(\)](#)
- `play_fitness`: Create graphs where edge probabilities are proportional to terminal node fitness scores. See [igraph::sample_fitness\(\)](#)
- `play_fitness_power`: Create graphs with an expected power-law degree distribution. See [igraph::sample_fitness_pl\(\)](#)
- `play_erdos_renyi`: Create graphs with a fixed edge probability or count. See [igraph::sample_gnp\(\)](#) and [igraph::sample_gnm\(\)](#)
- `play_geometry`: Create graphs by positioning nodes on a plane or torus and connecting nearby ones. See [igraph::sample_grg\(\)](#)

See Also

Other graph games: [component_games](#), [evolution_games](#), [type_games](#)

Examples

```
plot(play_erdos_renyi(20, 0.3))
```

search_graph	<i>Search a graph with depth first and breath first</i>
--------------	---

Description

These functions wraps the `igraph::bfs()` and `igraph::dfs()` functions to provide a consistent return value that can be used in `dplyr::mutate()` calls. Each function returns an integer vector with values matching the order of the nodes in the graph.

Usage

```
bfs_rank(root, mode = "out", unreachable = FALSE)
bfs_parent(root, mode = "out", unreachable = FALSE)
bfs_before(root, mode = "out", unreachable = FALSE)
bfs_after(root, mode = "out", unreachable = FALSE)
bfs_dist(root, mode = "out", unreachable = FALSE)
dfs_rank(root, mode = "out", unreachable = FALSE)
dfs_rank_out(root, mode = "out", unreachable = FALSE)
dfs_parent(root, mode = "out", unreachable = FALSE)
dfs_dist(root, mode = "out", unreachable = FALSE)
```

Arguments

root	The node to start the search from
mode	How edges are followed in the search if the graph is directed. "out" only follows outbound edges, "in" only follows inbound edges, and "all" or "total" follows all edges. This is ignored for undirected graphs.
unreachable	Should the search jump to a new component if the search is terminated without all nodes being visited? Default to FALSE (only reach connected nodes).

Value

An integer vector, the nature of which is determined by the function.

Functions

- `bfs_rank`: Get the succession in which the nodes are visited in a breath first search
- `bfs_parent`: Get the nodes from which each node is visited in a breath first search

- `bfs_before`: Get the node that was visited before each node in a breath first search
- `bfs_after`: Get the node that was visited after each node in a breath first search
- `bfs_dist`: Get the number of nodes between the root and each node in a breath first search
- `dfs_rank`: Get the succession in which the nodes are visited in a depth first search
- `dfs_rank_out`: Get the succession in which each nodes subtree is completed in a depth first search
- `dfs_parent`: Get the nodes from which each node is visited in a depth first search
- `dfs_dist`: Get the number of nodes between the root and each node in a depth first search

Examples

```
# Get the depth of each node in a tree
create_tree(10, 2) %>%
  activate(nodes) %>%
  mutate(depth = bfs_dist(root = 1))

# Reorder nodes based on a depth first search from node 3
create_notable('franklin') %>%
  activate(nodes) %>%
  mutate(order = dfs_rank(root = 3)) %>%
  arrange(order)
```

type_games

Graph games based on different node types

Description

This set of games are build around different types of nodes and simulating their interaction. The nature of their algorithm is described in detail at the linked [igraph documentation](#).

Usage

```
play_preference(n, n_types, p_type = rep(1, n_types), p_pref = matrix(1,
  n_types, n_types), fixed = FALSE, directed = TRUE, loops = FALSE)

play_preference_asym(n, n_types, p_type = matrix(1, n_types, n_types),
  p_pref = matrix(1, n_types, n_types), loops = FALSE)

play_bipartite(n1, n2, p, m, directed = TRUE, mode = "out")

play_traits(n, n_types, growth = 1, p_type = rep(1, n_types),
  p_pref = matrix(1, n_types, n_types), callaway = TRUE, directed = TRUE)

play_citation_type(n, growth, types = rep(0, n), p_pref = rep(1,
  length(unique(types))), directed = TRUE)
```

Arguments

n, n1, n2	The number of nodes in the graph. For bipartite graphs n1 and n2 specifies the number of nodes of each type.
n_types	The number of different node types in the graph
p_type	The probability that a node will be the given type. Either a vector or a matrix, depending on the game
p_pref	The probability that an edge will be made to a type. Either a vector or a matrix, depending on the game
fixed	Should n_types be understood as a fixed number of nodes for each type rather than as a probability
directed	Should the resulting graph be directed
loops	Are loop edges allowed
p	The probability of an edge occurring
m	The number of edges in the graph
mode	The flow direction of edges
growth	The number of edges added at each iteration
callaway	Use the callaway version of the trait based game
types	The type of each node in the graph, enumerated from 0

Value

A tbl_graph object

Functions

- `play_preference`: Create graphs by linking nodes of different types based on a defined probability. See [igraph::sample_pref\(\)](#)
- `play_preference_asym`: Create graphs by linking nodes of different types based on an asymmetric probability. See [igraph::sample_asym_pref\(\)](#)
- `play_bipartite`: Create bipartite graphs of fixed size and edge count or probability. See [igraph::sample_bipartite\(\)](#)
- `play_traits`: Create graphs by evolving a graph with type based edge probabilities. See [igraph::sample_traits\(\)](#) and [igraph::sample_traits_callaway\(\)](#)
- `play_citation_type`: Create citation graphs by evolving with type based linking probability. See [igraph::sample_cit_types\(\)](#) and [igraph::sample_cit_cit_types\(\)](#)

See Also

Other graph games: [component_games](#), [evolution_games](#), [sampling_games](#)

Examples

```
plot(play_bipartite(20, 30, 0.4))
```

Index

.E (context_accessors), 10
.G (context_accessors), 10
.N (context_accessors), 10

activate, 2
activate(), 3
active (activate), 2
as_tbl_graph (as_tbl_graph.data.frame),
3
as_tbl_graph(), 16
as_tbl_graph.data.frame, 3
as_tibble(), 3

bfs_after (search_graph), 41
bfs_before (search_graph), 41
bfs_dist (search_graph), 41
bfs_parent (search_graph), 41
bfs_rank (search_graph), 41
bind_edges (bind_graphs), 6
bind_graphs, 6
bind_nodes (bind_graphs), 6

centrality, 7, 34
centrality_alpha (centrality), 7
centrality_authority (centrality), 7
centrality_betweenness (centrality), 7
centrality_closeness (centrality), 7
centrality_degree (centrality), 7
centrality_edge_betweenness
(centrality), 7
centrality_eigen (centrality), 7
centrality_hub (centrality), 7
centrality_pagerank (centrality), 7
centrality_power (centrality), 7
centrality_subgraph (centrality), 7
component_games, 9, 15, 40, 43
context_accessors, 10
create_bipartite (create_graphs), 11
create_chordal_ring (create_graphs), 11
create_citation (create_graphs), 11
create_complete (create_graphs), 11
create_de_bruijn (create_graphs), 11
create_empty (create_graphs), 11
create_graphs, 11
create_kautz (create_graphs), 11
create_lattice (create_graphs), 11
create_notable (create_graphs), 11
create_path (create_graphs), 11
create_ring (create_graphs), 11
create_star (create_graphs), 11
create_tree (create_graphs), 11
crystallise (morph), 30
crystallize (morph), 30

dfs_dist (search_graph), 41
dfs_parent (search_graph), 41
dfs_rank (search_graph), 41
dfs_rank_out (search_graph), 41
dplyr::bind_rows(), 6, 15
dplyr::mutate(), 7, 41

edge_is_loop (edge_types), 13
edge_is_multiple (edge_types), 13
edge_is_mutual (edge_types), 13
edge_types, 13
evolution_games, 10, 13, 40, 43

filter(), 32

graph_adhesion (graph_measures), 16
graph_assortativity (graph_measures), 16
graph_asym_count (graph_measures), 16
graph_automorphisms (graph_measures), 16
graph_clique_count (graph_measures), 16
graph_clique_num (graph_measures), 16
graph_component_count (graph_measures),
16
graph_diameter (graph_measures), 16
graph_girth (graph_measures), 16
graph_join, 15

graph_join(), 6
graph_mean_dist (graph_measures), 16
graph_measures, 16
graph_min_cut (graph_measures), 16
graph_motif_count (graph_measures), 16
graph_mutual_count (graph_measures), 16
graph_order (graph_measures), 16
graph_radius (graph_measures), 16
graph_reciprocity (graph_measures), 16
graph_size (graph_measures), 16
graph_unconn_count (graph_measures), 16
group_biconnected_component
 (group_graph), 19
group_by(), 3, 32
group_components (group_graph), 19
group_edge_betweenness (group_graph), 19
group_fast_greedy (group_graph), 19
group_graph, 19
group_infomap (group_graph), 19
group_label_prop (group_graph), 19
group_leading_eigen (group_graph), 19
group_louvain (group_graph), 19
group_optimal (group_graph), 19
group_spinglass (group_graph), 19
group_walktrap (group_graph), 19
igraph::alpha centrality(), 8
igraph::as.igraph(), 5
igraph::assortativity(), 18
igraph::authority_score(), 8
igraph::automorphisms(), 18
igraph::betweenness(), 8
igraph::bfs(), 41
igraph::bibcoupling(), 38
igraph::biconnected_components(), 20
igraph::clique_num(), 18
igraph::closeness(), 8
igraph::cluster_edge_betweenness(), 20
igraph::cluster_fast_greedy(), 20
igraph::cluster_infomap(), 20
igraph::cluster_label_prop(), 20
igraph::cluster_leading_eigen(), 20
igraph::cluster_louvain(), 20
igraph::cluster_optimal(), 20
igraph::cluster_spinglass(), 20
igraph::cluster_walktrap(), 20
igraph::cocitation(), 38
igraph::components(), 20
igraph::constraint(), 34
igraph::coreness(), 34
igraph::count_components(), 18
igraph::count_max_cliques(), 18
igraph::count_motifs(), 18
igraph::count_triangles(), 22
igraph::degree(), 8
igraph::dfs(), 41
igraph::diameter(), 18
igraph::distances(), 38
igraph::diversity(), 34
igraph::dominator_tree(), 35
igraph::dyad_census(), 18, 19
igraph::edge_betweenness(), 8
igraph::edge_connectivity(), 18, 38
igraph::ego(), 22
igraph::ego_size(), 22
igraph::eigen centrality(), 8
igraph::estimate_betweenness(), 8
igraph::estimate_closeness(), 8
igraph::girth(), 18
igraph::gorder(), 19
igraph::gsize(), 19
igraph::hub_score(), 8
igraph::knn(), 22
igraph::local_scan(), 29
igraph::make_chordal_ring(), 12
igraph::make_graph(), 12
igraph::max_flow(), 38
igraph::mean_distance(), 19
igraph::min_cut(), 19
igraph::page_rank(), 8
igraph::power centrality(), 8
igraph::radius(), 18
igraph::reciprocity(), 19
igraph::sample_asym_pref(), 43
igraph::sample_bipartite(), 43
igraph::sample_cit_cit_types(), 43
igraph::sample_cit_types(), 43
igraph::sample_degseq(), 40
igraph::sample_dot_product(), 40
igraph::sample_fitness(), 40
igraph::sample_fitness_pl(), 40
igraph::sample_forestfire(), 15
igraph::sample_gnm(), 40
igraph::sample_gnp(), 40
igraph::sample_grg(), 40
igraph::sample_growing(), 15
igraph::sample_hierarchical_sbm(), 10

- igraph::sample_islands(), 10
- igraph::sample_last_cit(), 15
- igraph::sample_pa(), 15
- igraph::sample_pa_age(), 15
- igraph::sample_pref(), 43
- igraph::sample_sbm(), 10
- igraph::sample_smallworld(), 10
- igraph::sample_traits(), 43
- igraph::sample_traits_callaway(), 43
- igraph::similarity(), 38
- igraph::strength(), 8
- igraph::subgraph_centrality(), 8
- igraph::topo_sort(), 35
- igraph::transitivity(), 22
- igraph::vertex_connectivity(), 38
- is.tbl_graph(as.tbl_graph.data.frame), 3

- local_ave_degree(local_graph), 21
- local_graph, 21
- local_members(local_graph), 21
- local_size(local_graph), 21
- local_transitivity(local_graph), 21
- local_triangles(local_graph), 21

- map_bfs, 22, 25, 27, 28
- map_bfs(), 24, 29
- map_bfs_back, 23, 24, 27, 28
- map_bfs_back(), 22
- map_bfs_back_chr(map_bfs_back), 24
- map_bfs_back_dbl(map_bfs_back), 24
- map_bfs_back_int(map_bfs_back), 24
- map_bfs_back_lgl(map_bfs_back), 24
- map_bfs_chr(map_bfs), 22
- map_bfs_dbl(map_bfs), 22
- map_bfs_int(map_bfs), 22
- map_bfs_lgl(map_bfs), 22
- map_dfs, 23, 25, 26, 28
- map_dfs(), 27, 29
- map_dfs_back, 23, 25, 27, 27
- map_dfs_back(), 26
- map_dfs_back_chr(map_dfs_back), 27
- map_dfs_back_dbl(map_dfs_back), 27
- map_dfs_back_int(map_dfs_back), 27
- map_dfs_back_lgl(map_dfs_back), 27
- map_dfs_chr(map_dfs), 26
- map_dfs_dbl(map_dfs), 26
- map_dfs_int(map_dfs), 26
- map_dfs_lgl(map_dfs), 26

- map_local, 29
- map_local_chr(map_local), 29
- map_local_dbl(map_local), 29
- map_local_int(map_local), 29
- map_local_lgl(map_local), 29
- morph, 30
- morph(), 31
- morphers, 30, 31

- node_adhesion_from(pair_measures), 37
- node_adhesion_to(pair_measures), 37
- node_bibcoupling_with(pair_measures), 37
- node_cocitation_with(pair_measures), 37
- node_cohesion_from(pair_measures), 37
- node_cohesion_to(pair_measures), 37
- node_constraint(node_measures), 34
- node_coreness(node_measures), 34
- node_distance_from(pair_measures), 37
- node_distance_to(pair_measures), 37
- node_diversity(node_measures), 34
- node_dominator(node_topology), 35
- node_eccentricity(node_measures), 34
- node_is_center(node_types), 35
- node_is_cut(node_types), 35
- node_is_isolated(node_types), 35
- node_is_leaf(node_types), 35
- node_is_root(node_types), 35
- node_is_simplicial(node_types), 35
- node_is_sink(node_types), 35
- node_is_source(node_types), 35
- node_is_universal(node_types), 35
- node_max_flow_from(pair_measures), 37
- node_max_flow_to(pair_measures), 37
- node_measures, 34
- node_similarity_with(pair_measures), 37
- node_topo_order(node_topology), 35
- node_topology, 35
- node_types, 35

- pair_measures, 37
- play_barabasi_albert(evolution_games), 13
- play_barabasi_albert_aging(evolution_games), 13
- play_bipartite(type_games), 42
- play_blocks(component_games), 9
- play_blocks_hierarchy(component_games), 9

`play_citation_age` (`evolution_games`), 13
`play_citation_type` (`type_games`), 42
`play_citation_type()`, 15
`play_degree` (`sampling_games`), 39
`play_dotprod` (`sampling_games`), 39
`play_erdos_renyi` (`sampling_games`), 39
`play_fitness` (`sampling_games`), 39
`play_fitness_power` (`sampling_games`), 39
`play_forestfire` (`evolution_games`), 13
`play_geometry` (`sampling_games`), 39
`play_growing` (`evolution_games`), 13
`play_islands` (`component_games`), 9
`play_preference` (`type_games`), 42
`play_preference_asym` (`type_games`), 42
`play_smallworld` (`component_games`), 9
`play_traits` (`type_games`), 42
`play_traits()`, 15

`reroute`, 38

`sampling_games`, 10, 15, 39, 43
`search_graph`, 41
`strength`, 21

`tbl_graph`, 2
`tbl_graph` (`as_tbl_graph.data.frame`), 3
`to_bfs_tree` (`morphers`), 31
`to_complement` (`morphers`), 31
`to_components` (`morphers`), 31
`to_contracted` (`morphers`), 31
`to_dfs_tree` (`morphers`), 31
`to_dominator_tree` (`morphers`), 31
`to_linegraph`, 31
`to_linegraph` (`morphers`), 31
`to_local_neighborhood` (`morphers`), 31
`to_minimum_spanning_tree` (`morphers`), 31
`to_shortest_path` (`morphers`), 31
`to_simple` (`morphers`), 31
`to_split` (`morphers`), 31
`to_subgraph` (`morphers`), 31
`type_games`, 10, 15, 40, 42

`unmorph` (`morph`), 30