cdatastruct

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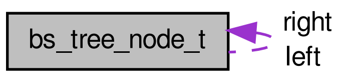
Data Structure Documentation

3.1 bs_tree_node_t Struct Reference

Struct for binary search tree node.

`#include <cds_bs_tree.h>`

Collaboration diagram for bs_tree_node_t:



Data Fields

- void ∗ data
- struct bs_tree_node_t ∗ left
- struct bs_tree_node_t ∗ right

3.1.1 Detailed Description

Struct for binary search tree node.

3.1.2 Field Documentation

3.1.2.1 void∗ bs_tree_node_t::data

Pointer to data

3.1.2.2 struct bs_tree_node_t∗ bs_tree_node_t::left

Pointer to left child node

3.1.2.3 struct bs_tree_node_t* bs_tree_node_t::right

Pointer to right child node

The documentation for this struct was generated from the following file:

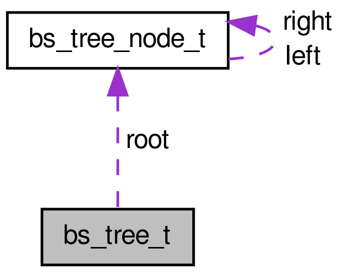
- cds_bs_tree.h

3.2 bs_tree_t Struct Reference

Struct to contain a binary search tree.

```
#include <bs_tree.h>
```

Collaboration diagram for bs_tree_t:



Data Fields

- pthread_mutex_t mutex
- struct bs_tree_node_t * root
- size_t length
- int(* cfunc)()
- void(* free_func)()

3.2.1 Detailed Description

Struct to contain a binary search tree.

3.2.2 Field Documentation

3.2.2.1 int(* bs_tree_t::cfunc)()

Pointer to compare function

3.2.2.2 void(* bs_tree_t::free_func)()

Pointer to node free function

3.2.2.3 size_t bs_tree_t::length

Length of list

3.2.2.4 pthread_mutex_t bs_tree_t::mutex

Mutex

3.2.2.5 struct **bs_tree_node_t**∗ bs_tree_t::root

Pointer to root node

The documentation for this struct was generated from the following file:

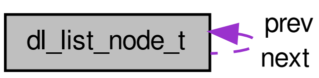
- bs_tree.h

3.3 dl_list_node_t Struct Reference

Struct for double linked list node.

`#include <cds_dl_list.h>`

Collaboration diagram for dl_list_node_t:



Data Fields

- void ∗ data
- struct dl_list_node_t ∗ next
- struct dl_list_node_t ∗ prev

3.3.1 Detailed Description

Struct for double linked list node.

3.3.2 Field Documentation

3.3.2.1 void∗ dl_list_node_t::data

Pointer to data

3.3.2.2 struct **dl_list_node_t**∗ dl_list_node_t::next

Pointer to next node

3.3.2.3 struct dl_list_node_t∗ dl_list_node_t::prev

Pointer to previous node

The documentation for this struct was generated from the following file:

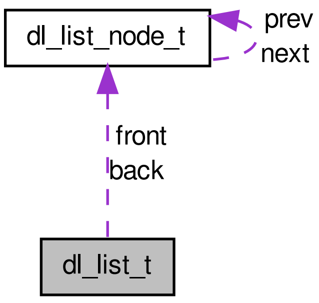
- cds_dl_list.h

3.4 dl_list_t Struct Reference

Struct to contain a list.

`#include <dl_list.h>`

Collaboration diagram for dl_list_t:



Data Fields

- pthread_mutex_t mutex
- struct dl_list_node_t ∗ front
- struct dl_list_node_t ∗ back
- size_t length
- int(∗ cfunc)()
- void(∗ free_func)()

3.4.1 Detailed Description

Struct to contain a list.

3.4.2 Field Documentation

3.4.2.1 struct dl_list_node_t∗ dl_list_t::back

Pointer to last node

3.4.2.2 int(∗ dl_list_t::cfunc)()

Pointer to compare function

3.4.2.3 void(∗ dl_list_t::free_func)()

Pointer to free function

3.4.2.4 struct dl_list_node_t∗ dl_list_t::front

Pointer to first node

3.4.2.5 size_t dl_list_t::length

Length of list

3.4.2.6 pthread_mutex_t dl_list_t::mutex

Mutex

The documentation for this struct was generated from the following file:

- dl_list.h

3.5 kvpair_t Struct Reference

Key-value pair struct.

Data Fields

- char ∗ key
- void ∗ value

3.5.1 Detailed Description

Key-value pair struct.

3.5.2 Field Documentation

3.5.2.1 char∗ kvpair_t::key

Key string

3.5.2.2 void∗ kvpair_t::value

Pointer to data

The documentation for this struct was generated from the following file:

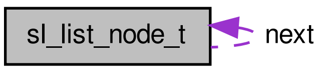
- bst_map.c

3.6 sl_list_node_t Struct Reference

Struct for singly linked list node.

`#include <cds_sl_list.h>`

Collaboration diagram for sl_list_node_t:



Data Fields

- void ∗ data
- struct sl_list_node_t ∗ next

3.6.1 Detailed Description

Struct for singly linked list node.

3.6.2 Field Documentation

3.6.2.1 void∗ sl_list_node_t::data

Pointer to data

3.6.2.2 struct sl_list_node_t∗ sl_list_node_t::next

Pointer to next node

The documentation for this struct was generated from the following file:

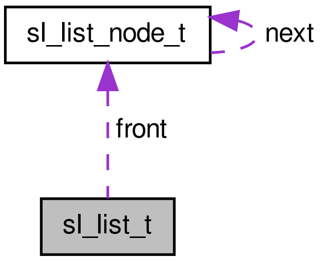
- cds_sl_list.h

3.7 sl_list_t Struct Reference

Struct to contain a list.

`#include <sl_list.h>`

Collaboration diagram for sl_list_t:



Data Fields

- pthread_mutex_t mutex
- struct sl_list_node_t ∗ front
- size_t length
- int(∗ cfunc)()
- void(∗ free_func)()

3.7.1 Detailed Description

Struct to contain a list.

3.7.2 Field Documentation

3.7.2.1 int(∗ sl_list_t::cfunc)()

Pointer to compare function

3.7.2.2 void(∗ sl_list_t::free_func)()

Pointer to free function

3.7.2.3 struct sl_list_node_t∗ sl_list_t::front

Pointer to first node

3.7.2.4 size_t sl_list_t::length

Length of list

3.7.2.5 pthread_mutex_t sl_list_t::mutex

Mutex

The documentation for this struct was generated from the following file:

- sl_list.h

Chapter 4

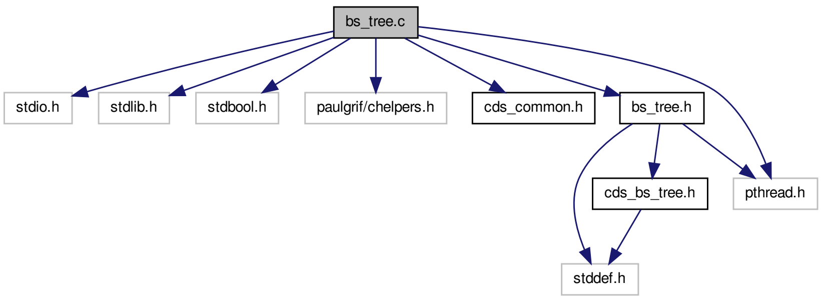
File Documentation

4.1 bs_tree.c File Reference

Implementation of binary search tree data structure.

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <paulgrif/chelpers.h>
#include "cds_common.h"
#include "bs_tree.h"
#include <pthread.h>
```

Include dependency graph for bs_tree.c:



Functions

- bs_tree bs_tree_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

  Initializes a new binary search tree.
- void bs_tree_free (bs_tree tree)

  Frees the resources associated with a tree.
- size_t bs_tree_length (const bs_tree tree)

  Returns the number of elements in a tree.
- bool bs_tree_isempty (const bs_tree tree)

  Checks if a tree is empty.
- bool bs_tree_search (const bs_tree tree, const void ∗data)

  Determines if a data element is in a tree.

- void ∗ bs_tree_search_data (const bs_tree tree, const void ∗data)

  Searches a tree for a piece of data and returns it.
- bool bs_tree_insert (bs_tree tree, void ∗data)

  Inserts data into a tree.
- void bs_tree_preorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a preorder left-to-right traversal of a bs_tree.
- void bs_tree_inorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs an inorder left-to-right traversal of a bs_tree.
- void bs_tree_postorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a postorder left-to-right traversal of a bs_tree.
- void bs_tree_preorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a preorder right-to-left traversal of a bs_tree.
- void bs_tree_inorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs an inorder right-to-left traversal of a bs_tree.
- void bs_tree_postorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a postorder right-to-left traversal of a bs_tree.
- void bs_tree_lock (bs_tree tree)

  Locks a tree's mutex.
- void bs_tree_unlock (bs_tree tree)

  Unlocks a tree's mutex.
- bs_tree_node bs_tree_new_node (void ∗data)

  Creates and allocates memory for a new node.
- void bs_tree_free_subtree (bs_tree tree, bs_tree_node node)

  Frees the resources associated with a subtree.
- bs_tree_node bs_tree_search_node (const bs_tree tree, const void ∗data)

  Searches a tree for a piece of data.
- bool bs_tree_insert_subtree (bs_tree tree, bs_tree_node ∗p_node, void ∗data)

  Inserts a data element into a subtree.
- bs_tree_node bs_tree_insert_search (bs_tree tree, void ∗data, bool ∗found)

  Searches a tree for insertion purposes.
- void bs_tree_preorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a preorder left-to-right traversal of a bs_tree.
- void bs_tree_inorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs an inorder left-to-right traversal of a bs_tree.
- void bs_tree_postorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a postorder left-to-right traversal of a bs_tree.
- void bs_tree_preorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a preorder right-to-left traversal of a bs_tree.
- void bs_tree_inorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs an inorder right-to-left traversal of a bs_tree.
- void bs_tree_postorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a postorder right-to-left traversal of a bs_tree.

4.1.1 Detailed Description

Implementation of binary search tree data structure.

Author

Paul Griffiths

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4.1.2 Function Documentation

4.1.2.1 void bs_tree_free (**bs_tree** *tree*)

Frees the resources associated with a tree.

Parameters

tree	A pointer to the tree to free.

4.1.2.2 void bs_tree_free_subtree (**bs_tree** *tree,* **bs_tree_node** *node*)

Frees the resources associated with a subtree.

This function frees the node recursively.

Parameters

tree	A pointer to the tree.
node	A pointer to the tree node at the root of the subtree.

4.1.2.3 **bs_tree** bs_tree_init (int(∗)(const void ∗, const void ∗) *cfunc,* void(∗)(void ∗) *free_func*)

Initializes a new binary search tree.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a free function. The function should return no value, and accept one parameter of type `void *`. If set to NULL, the standard C `free()` function is used. This function is useful when the data elements are structs which themselves contain dynamically allocated members, which need to be `free()`d before the overall struct is `free()`.

Returns

A pointer to the new tree.

4.1.2.4 void bs_tree_inorder_left_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs an inorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.5 void bs_tree_inorder_left_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs an inorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.6 void bs_tree_inorder_right_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs an inorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.7 void bs_tree_inorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs an inorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.8 bool bs_tree_insert (**bs_tree** *tree,* void ∗ *data*)

Inserts data into a tree.

Duplicated data is replaced. This is a superfluous operation for scalar data, but is necessary for structs, where 'found' may mean only one element of the struct compares equal, and other elements may be different (e.g. a map data structure).

Parameters

tree	A pointer to the tree.
data	The data to insert.

Returns

`true` if the data was already in the tree and has been replaced, `false` if it was not present and newly added.

4.1.2.9 bs_tree_node bs_tree_insert_search (bs_tree *tree*, void ∗ *data*, bool ∗ *found*)

Searches a tree for insertion purposes.

The function searches the tree for a piece of data, and if it is not found, returns a pointer to the node under which it should be inserted.

Parameters

tree	A pointer to the tree.
data	A pointer to the data for which to search.
found	A pointer to a `bool` to populate according to whether the data is already in the tree.

Returns

A pointer to the node in which the data was found, if it was found, or a pointer to the last node tried if it was not. The last tried node is the one under which the new data should be inserted, if it is not already in the tree.

4.1.2.10 bool bs_tree_insert_subtree (bs_tree *tree*, bs_tree_node ∗ *p_node*, void ∗ *data*)

Inserts a data element into a subtree.

The data element is replaced if it is found in the tree. This is a superfluous operation for scalar data, but is necessary for structs, where 'found' may mean only one of the struct members compares equal, and other data elements may differ. This function `free()`s the old data when this happens.

Parameters

tree	A pointer to the tree
p_node	A pointer to the pointer to the node at the root of the subtree.
data	A pointer to the data to which to insert.

Returns

`true` if the data was present and duplicated, 'false' if not.

4.1.2.11 bool bs_tree_isempty (const bs_tree *tree*)

Checks if a tree is empty.

Parameters

tree	A pointer to the tree.

Returns

`true` if the tree is empty, otherwise `false`.

4.1.2.12 size_t bs_tree_length (const **bs_tree** *tree*)

Returns the number of elements in a tree.

Parameters

tree	A pointer to the tree.

Returns

The number of elements in the tree.

4.1.2.13 void bs_tree_lock (**bs_tree** *tree*)

Locks a tree's mutex.

Parameters

tree	A pointer to the tree.

4.1.2.14 **bs_tree_node** bs_tree_new_node (void ∗ *data*)

Creates and allocates memory for a new node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly-created node.

4.1.2.15 void bs_tree_postorder_left_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a postorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.16 void bs_tree_postorder_left_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a postorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.17 void bs_tree_postorder_right_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a postorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.18 void bs_tree_postorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a postorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.19 void bs_tree_preorder_left_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a preorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.20 void bs_tree_preorder_left_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a preorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.21 void bs_tree_preorder_right_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a preorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.22 void bs_tree_preorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a preorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.1.2.23 bool bs_tree_search (const **bs_tree** *tree,* const void ∗ *data*)

Determines if a data element is in a tree.

Parameters

tree	A pointer to the tree.
data	The data for which to search.

Returns

`true` is the data is found, `false` otherwise.

4.1.2.24 void∗ bs_tree_search_data (const **bs_tree** *tree,* const void ∗ *data*)

Searches a tree for a piece of data and returns it.

Parameters

tree	A pointer to the tree.
data	The data for which to search.

Returns

A pointer to the data if found, `NULL` otherwise.

4.1.2.25 **bs_tree_node** bs_tree_search_node (const **bs_tree** *tree,* const void ∗ *data*)

Searches a tree for a piece of data.

Parameters

tree	A pointer to the tree.
data	A pointer to the data for which to search.

Returns

A pointer to the node in which the data was found, or `NULL` if the data was not found.

4.1.2.26 void bs_tree_unlock (**bs_tree** *tree*)

Unlocks a tree's mutex.

Parameters

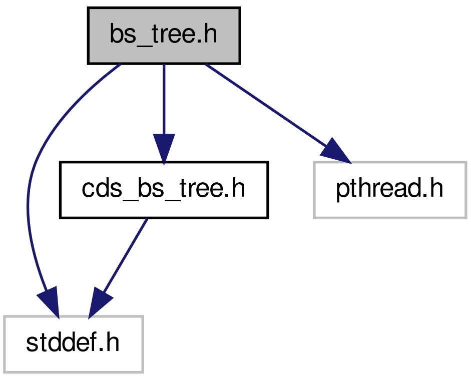
tree	A pointer to the tree.

4.2 bs_tree.h File Reference

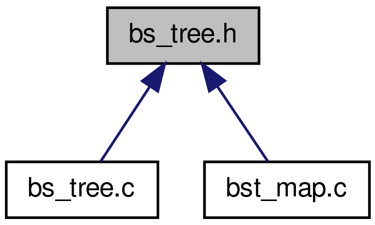
Developer interface to binary search tree data structure.

```
#include <stddef.h>
#include "cds_bs_tree.h"
#include <pthread.h>
```

Include dependency graph for bs_tree.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct bs_tree_t

  Struct to contain a binary search tree.

Macros

- #define _POSIX_C_SOURCE 200809L

  Enable POSIX library.

Typedefs

- typedef struct bs_tree_t sl_list_t

  Struct to contain a binary search tree.
- typedef struct bs_tree_node_t ∗ bs_tree_node

  Typedef for binary search tree node.

Functions

- bs_tree_node bs_tree_new_node (void ∗data)

  Creates and allocates memory for a new node.
- void bs_tree_free_subtree (bs_tree tree, bs_tree_node node)

  Frees the resources associated with a subtree.
- bs_tree_node bs_tree_search_node (const bs_tree tree, const void ∗key)

  Searches a tree for a piece of data.
- bool bs_tree_insert_subtree (bs_tree tree, bs_tree_node ∗p_node, void ∗data)

  Inserts a data element into a subtree.
- bs_tree_node bs_tree_insert_search (bs_tree tree, void ∗key, bool ∗found)

  Searches a tree for insertion purposes.
- void bs_tree_preorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a preorder left-to-right traversal of a bs_tree.
- void bs_tree_inorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs an inorder left-to-right traversal of a bs_tree.

- void bs_tree_postorder_left_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a postorder left-to-right traversal of a bs_tree.
- void bs_tree_preorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a preorder right-to-left traversal of a bs_tree.
- void bs_tree_inorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs an inorder right-to-left traversal of a bs_tree.
- void bs_tree_postorder_right_traverse_int (bs_tree tree, bs_tree_node node, void(∗dfunc)(void ∗, void ∗), void ∗arg)

  Performs a postorder right-to-left traversal of a bs_tree.

4.2.1 Detailed Description

Developer interface to binary search tree data structure.

Author

Paul Griffiths

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4.2.2 Function Documentation

4.2.2.1 void bs_tree_free_subtree (bs_tree *tree,* bs_tree_node *node*)

Frees the resources associated with a subtree.

This function frees the node recursively.

Parameters

tree	A pointer to the tree.
node	A pointer to the tree node at the root of the subtree.

4.2.2.2 void bs_tree_inorder_left_traverse_int (bs_tree *tree,* bs_tree_node *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs an inorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.3 void bs_tree_inorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs an inorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.4 **bs_tree_node** bs_tree_insert_search (**bs_tree** *tree,* void ∗ *data,* bool ∗ *found*)

Searches a tree for insertion purposes.

The function searches the tree for a piece of data, and if it is not found, returns a pointer to the node under which it should be inserted.

Parameters

tree	A pointer to the tree.
data	A pointer to the data for which to search.
found	A pointer to a `bool` to populate according to whether the data is already in the tree.

Returns

A pointer to the node in which the data was found, if it was found, or a pointer to the last node tried if it was not. The last tried node is the one under which the new data should be inserted, if it is not already in the tree.

4.2.2.5 bool bs_tree_insert_subtree (**bs_tree** *tree,* **bs_tree_node** ∗ *p_node,* void ∗ *data*)

Inserts a data element into a subtree.

The data element is replaced if it is found in the tree. This is a superfluous operation for scalar data, but is necessary for structs, where 'found' may mean only one of the struct members compares equal, and other data elements may differ. This function `free()`s the old data when this happens.

Parameters

tree	A pointer to the tree
p_node	A pointer to the pointer to the node at the root of the subtree.
data	A pointer to the data to which to insert.

Returns

`true` if the data was present and duplicated, 'false' if not.

4.2.2.6 **bs_tree_node** bs_tree_new_node (void ∗ *data*)

Creates and allocates memory for a new node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly-created node.

4.2.2.7 void bs_tree_postorder_left_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a postorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.8 void bs_tree_postorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a postorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.9 void bs_tree_preorder_left_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a preorder left-to-right traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.10 void bs_tree_preorder_right_traverse_int (**bs_tree** *tree,* **bs_tree_node** *node,* void(∗)(void ∗, void ∗) *dfunc,* void ∗ *arg*)

Performs a preorder right-to-left traversal of a bs_tree.

This function is called internally by the matching function that the library user calls.

Parameters

tree	A pointer to the tree.
node	A pointer to the current node.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.2.2.11 bs_tree_node bs_tree_search_node (const bs_tree *tree*, const void ∗ *data*)

Searches a tree for a piece of data.

Parameters

tree	A pointer to the tree.
data	A pointer to the data for which to search.

Returns

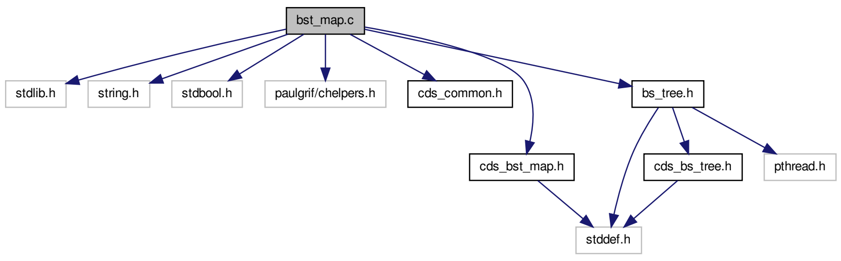
A pointer to the node in which the data was found, or `NULL` if the data was not found.

4.3 bst_map.c File Reference

Implementation of binary search tree map data structure.

```
#include <stdlib.h>
#include <string.h>
#include <stdbool.h>
#include <paulgrif/chelpers.h>
#include "cds_common.h"
#include "cds_bst_map.h"
#include "bs_tree.h"
```

Include dependency graph for bst_map.c:



Data Structures

- struct kvpair_t

  Key-value pair struct.

Typedefs

- typedef struct kvpair_t kvpair_t

  Key-value pair struct.

- typedef struct kvpair_t ∗ kvpair

  Typedef for kvpair pointer.

Functions

- bst_map bst_map_init (void)

  Initializes a new binary search tree map.
- void bst_map_free (bst_map map)

  Frees the resources associated with a BST map.
- size_t bst_map_length (const bst_map map)

  Returns the number of elements in a BST map.
- bool bst_map_isempty (const bst_map map)

  Checks if a map is empty.
- bool bst_map_search (const bst_map map, const char ∗key)

  Determines if a key is in a map.
- void ∗ bst_map_search_data (const bst_map map, const char ∗key)

  Searches a map for a value matching a key and returns it.
- bool bst_map_insert (bst_map map, const char ∗key, void ∗value)

  Inserts a key-value pair into a map.
- void bst_map_lock (bst_map map)

  Locks a map's mutex.
- void bst_map_unlock (bst_map map)

  Unlocks a map's mutex.

4.3.1 Detailed Description

Implementation of binary search tree map data structure.

Author

Paul Griffiths

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4.3.2 Function Documentation

4.3.2.1 void bst_map_free (**bst_map** *map*)

Frees the resources associated with a BST map.

Parameters

map	A pointer to the map to free.

4.3.2.2 **bst_map** bst_map_init (void)

Initializes a new binary search tree map.

Returns

A pointer to the new map.

4.3.2.3 bool bst_map_insert (bst_map *map*, const char * *key*, void * *value*)

Inserts a key-value pair into a map.

The value is replaced if the key is already found in the map. Any memory consumed by the old value is automatically `free()`d.

Parameters

map	A pointer to the map.
key	The key of the new value to insert.
value	A pointer to the new value to insert.

Returns

`true` if the key was already in the tree and the value has been replaced, `false` if the key was not present.

4.3.2.4 bool bst_map_isempty (const bst_map *map*)

Checks if a map is empty.

Parameters

map	A pointer to the map.

Returns

`true` if the map is empty, otherwise `false`.

4.3.2.5 size_t bst_map_length (const bst_map *map*)

Returns the number of elements in a BST map.

Parameters

map	A pointer to the map.

Returns

The number of elements in the map.

4.3.2.6 void bst_map_lock (bst_map *map*)

Locks a map's mutex.

Parameters

map	A pointer to the map.

4.3.2.7 bool bst_map_search (const bst_map *map,* const char * *key*)

Determines if a key is in a map.

Parameters

map	A pointer to the map.
key	The key for which to search.

Returns

`true` is the key is found, `false` otherwise.

4.3.2.8 void* bst_map_search_data (const bst_map *map,* const char * *key*)

Searches a map for a value matching a key and returns it.

Parameters

map	A pointer to the map.
key	The key for which to search.

Returns

A pointer to the value if found, `NULL` otherwise.

4.3.2.9 void bst_map_unlock (bst_map *map*)

Unlocks a map's mutex.

Parameters

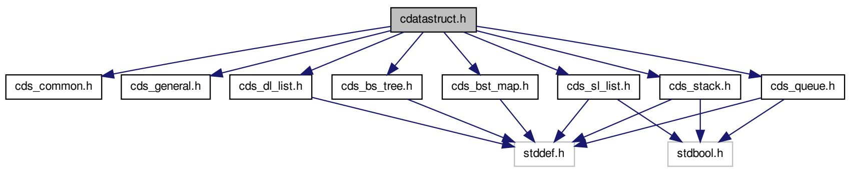
map	A pointer to the map.

4.4 cdatastruct.h File Reference

Interface to generic C data structures.

```
#include "cds_common.h"
#include "cds_general.h"
#include "cds_sl_list.h"
#include "cds_dl_list.h"
#include "cds_stack.h"
#include "cds_queue.h"
#include "cds_bs_tree.h"
#include "cds_bst_map.h"
```

Include dependency graph for cdatastruct.h:



4.4.1 Detailed Description

Interface to generic C data structures. Interface to generic C data structures.

Author

Paul Griffiths

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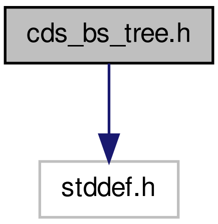
4.5 cds_bs_tree.h File Reference

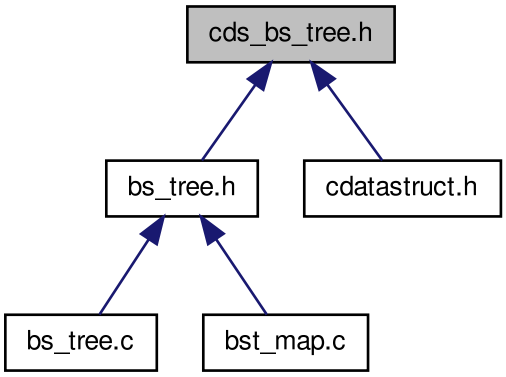
User interface to binary search tree data structure.

```
#include <stddef.h>
```

Include dependency graph for cds_bs_tree.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct bs_tree_node_t

  Struct for binary search tree node.

Typedefs

- typedef struct bs_tree_node_t bs_tree_node_t

  Struct for binary search tree node.
- typedef struct bs_tree_t ∗ bs_tree

  Typedef for tree pointer.

Functions

- bs_tree bs_tree_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

  Initializes a new binary search tree.
- void bs_tree_free (bs_tree tree)

  Frees the resources associated with a tree.
- bool bs_tree_isempty (const bs_tree tree)

  Checks if a tree is empty.
- size_t bs_tree_length (const bs_tree tree)

  Returns the number of elements in a tree.
- bool bs_tree_insert (bs_tree tree, void ∗data)

  Inserts data into a tree.
- bool bs_tree_search (const bs_tree tree, const void ∗data)

  Determines if a data element is in a tree.
- void ∗ bs_tree_search_data (const bs_tree tree, const void ∗data)

  Searches a tree for a piece of data and returns it.
- void bs_tree_preorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a preorder left-to-right traversal of a bs_tree.

- void bs_tree_inorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs an inorder left-to-right traversal of a bs_tree.
- void bs_tree_postorder_left_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a postorder left-to-right traversal of a bs_tree.
- void bs_tree_preorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a preorder right-to-left traversal of a bs_tree.
- void bs_tree_inorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs an inorder right-to-left traversal of a bs_tree.
- void bs_tree_postorder_right_traverse (bs_tree tree, void(∗dfunc)(void ∗, void ∗arg), void ∗arg)

  Performs a postorder right-to-left traversal of a bs_tree.
- void bs_tree_lock (bs_tree tree)

  Locks a tree's mutex.
- void bs_tree_unlock (bs_tree tree)

  Unlocks a tree's mutex.

4.5.1 Detailed Description

User interface to binary search tree data structure.

Author

Paul Griffiths

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4.5.2 Function Documentation

4.5.2.1 void bs_tree_free (bs_tree *tree*)

Frees the resources associated with a tree.

Parameters

tree	A pointer to the tree to free.

4.5.2.2 bs_tree bs_tree_init (int(∗)(const void ∗, const void ∗) *cfunc,* void(∗)(void ∗) *free_func*)

Initializes a new binary search tree.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a free function. The function should return no value, and accept one parameter of type `void *`. If set to NULL, the standard C `free()` function is used. This function is useful when the data elements are structs which themselves contain dynamically allocated members, which need to be `free()`d before the overall struct is `free()`.

Returns

A pointer to the new tree.

4.5.2.3 void bs_tree_inorder_left_traverse (bs_tree *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs an inorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.4 void bs_tree_inorder_right_traverse (bs_tree *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs an inorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.5 bool bs_tree_insert (bs_tree *tree,* void ∗ *data*)

Inserts data into a tree.

Duplicated data is replaced. This is a superfluous operation for scalar data, but is necessary for structs, where 'found' may mean only one element of the struct compares equal, and other elements may be different (e.g. a map data structure).

Parameters

tree	A pointer to the tree.
data	The data to insert.

Returns

`true` if the data was already in the tree and has been replaced, `false` if it was not present and newly added.

4.5.2.6 bool bs_tree_isempty (const bs_tree *tree*)

Checks if a tree is empty.

Parameters

tree	A pointer to the tree.

Returns

`true` if the tree is empty, otherwise `false`.

4.5.2.7 size_t bs_tree_length (const **bs_tree** *tree*)

Returns the number of elements in a tree.

Parameters

tree	A pointer to the tree.

Returns

The number of elements in the tree.

4.5.2.8 void bs_tree_lock (**bs_tree** *tree*)

Locks a tree's mutex.

Parameters

tree	A pointer to the tree.

4.5.2.9 void bs_tree_postorder_left_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a postorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.10 void bs_tree_postorder_right_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a postorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.11 void bs_tree_preorder_left_traverse (**bs_tree** *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a preorder left-to-right traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.12 void bs_tree_preorder_right_traverse (bs_tree *tree,* void(∗)(void ∗, void ∗arg) *dfunc,* void ∗ *arg*)

Performs a preorder right-to-left traversal of a bs_tree.

Parameters

tree	A pointer to the tree.
dfunc	A pointer to the function to invoke for each node.
arg	A pointer to the argument to pass to `dfunc()`.

4.5.2.13 bool bs_tree_search (const bs_tree *tree,* const void ∗ *data*)

Determines if a data element is in a tree.

Parameters

tree	A pointer to the tree.
data	The data for which to search.

Returns

`true` is the data is found, `false` otherwise.

4.5.2.14 void∗ bs_tree_search_data (const bs_tree *tree,* const void ∗ *data*)

Searches a tree for a piece of data and returns it.

Parameters

tree	A pointer to the tree.
data	The data for which to search.

Returns

A pointer to the data if found, `NULL` otherwise.

4.5.2.15 void bs_tree_unlock (bs_tree *tree*)

Unlocks a tree's mutex.

Parameters

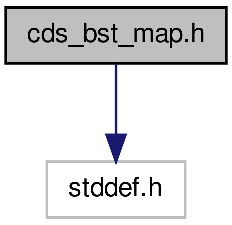
tree	A pointer to the tree.

4.6 cds_bst_map.h File Reference

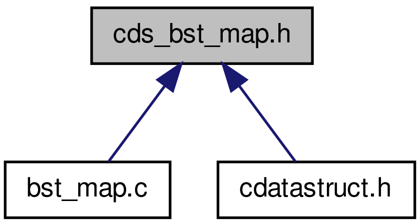
User interface to binary search tree map data structure.

```
#include <stddef.h>
```

Include dependency graph for cds_bst_map.h:



This graph shows which files directly or indirectly include this file:



Typedefs

- typedef struct bs_tree_t ∗ bst_map

    Typedef for map pointer.

Functions

- bst_map bst_map_init (void)

    Initializes a new binary search tree map.
- void bst_map_free (bst_map map)

    Frees the resources associated with a BST map.
- bool bst_map_isempty (const bst_map map)

    Checks if a map is empty.
- size_t bst_map_length (const bst_map map)

    Returns the number of elements in a BST map.
- bool bst_map_insert (bst_map map, const char ∗key, void ∗value)

    Inserts a key-value pair into a map.
- bool bst_map_search (const bst_map map, const char ∗key)

    Determines if a key is in a map.

- void ∗ bst_map_search_data (const bst_map map, const char ∗key)

  Searches a map for a value matching a key and returns it.
- void bst_map_lock (bst_map map)

  Locks a map's mutex.
- void bst_map_unlock (bst_map map)

  Unlocks a map's mutex.

4.6.1 Detailed Description

User interface to binary search tree map data structure.

Author

Paul Griffiths

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4.6.2 Function Documentation

4.6.2.1 void bst_map_free (bst_map *map*)

Frees the resources associated with a BST map.

Parameters

map	A pointer to the map to free.

4.6.2.2 bst_map bst_map_init (void)

Initializes a new binary search tree map.

Returns

A pointer to the new map.

4.6.2.3 bool bst_map_insert (bst_map *map,* const char ∗ *key,* void ∗ *value*)

Inserts a key-value pair into a map.

The value is replaced if the key is already found in the map. Any memory consumed by the old value is automatically `free()`d.

Parameters

map	A pointer to the map.
key	The key of the new value to insert.
value	A pointer to the new value to insert.

Returns

`true` if the key was already in the tree and the value has been replaced, `false` if the key was not present.

4.6.2.4 bool bst_map_isempty (const bst_map *map*)

Checks if a map is empty.

Parameters

map	A pointer to the map.

Returns

`true` if the map is empty, otherwise `false`.

4.6.2.5 size_t bst_map_length (const bst_map *map*)

Returns the number of elements in a BST map.

Parameters

map	A pointer to the map.

Returns

The number of elements in the map.

4.6.2.6 void bst_map_lock (bst_map *map*)

Locks a map's mutex.

Parameters

map	A pointer to the map.

4.6.2.7 bool bst_map_search (const bst_map *map,* const char * *key*)

Determines if a key is in a map.

Parameters

map	A pointer to the map.
key	The key for which to search.

Returns

`true` is the key is found, `false` otherwise.

4.6.2.8 void* bst_map_search_data (const bst_map *map,* const char * *key*)

Searches a map for a value matching a key and returns it.

Parameters

map	A pointer to the map.
key	The key for which to search.

Returns

A pointer to the value if found, `NULL` otherwise.

4.6.2.9 void bst_map_unlock (**bst_map** *map*)

Unlocks a map's mutex.

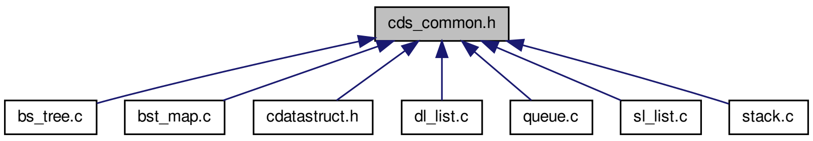
Parameters

map	A pointer to the map.

4.7 cds_common.h File Reference

Common data types and data for C data structures library.

This graph shows which files directly or indirectly include this file:



Typedefs

- typedef enum cds_error cds_error

    Enumeration of return error codes.

Enumerations

- enum cds_error { CDSERR_ERROR = -1, CDSERR_OUTOFRANGE = -2, CDSERR_NOTFOUND = -3, C-DSERR_BADITERATOR = -4 }

    Enumeration of return error codes.

4.7.1 Detailed Description

Common data types and data for C data structures library.

Author

Paul Griffiths

Copyright

4.7.2 Enumeration Type Documentation

4.7.2.1 enum cds_error

Enumeration of return error codes.

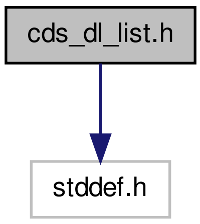
Enumerator:

CDSERR_ERROR	Unspecified error
CDSERR_OUTOFRANGE	Index out of range
CDSERR_NOTFOUND	Data element not found
CDSERR_BADITERATOR	Invalid iterator

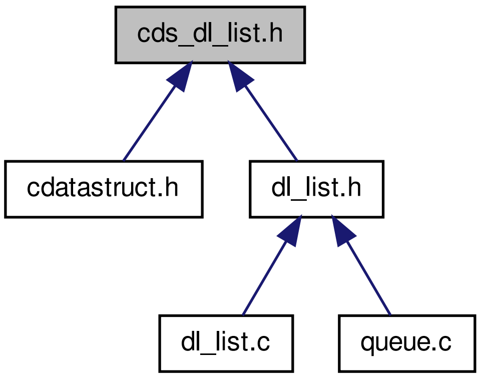
4.8 cds_dl_list.h File Reference

User interface to doubly linked list data structure.

`#include <stddef.h>`
Include dependency graph for cds_dl_list.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct dl_list_node_t

  Struct for double linked list node.

Typedefs

- typedef struct dl_list_node_t dl_list_node_t

  Struct for double linked list node.
- typedef struct dl_list_t ∗ dl_list

  Typedef for list pointer.
- typedef struct dl_list_node_t ∗ dl_list_itr

  Typedef for list iterator.

Functions

- dl_list dl_list_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

  Initializes a new doubly linked list.
- void dl_list_free (dl_list list)

  Frees the resources associated with a list.
- size_t dl_list_length (const dl_list list)

  Returns the number of elements in a list.
- bool dl_list_isempty (const dl_list list)

  Checks if a list is empty.
- void dl_list_prepend (dl_list list, void ∗data)

  Inserts an element at the beginning of a list.
- void dl_list_append (dl_list list, void ∗data)

  Inserts an element at the end of a list.
- int dl_list_insert_before (dl_list list, const dl_list_itr itr, void ∗data)

  Inserts an element before a provided iterator.

- int dl_list_insert_at (dl_list list, const size_t index, void ∗data)

  Inserts an element at the specified index of a list.
- int dl_list_insert_after (dl_list list, const dl_list_itr itr, void ∗data)

  Inserts an element after a provided iterator.
- int dl_list_delete_at (dl_list list, const size_t index)

  Deletes a list element at a specified index.
- int dl_list_find_index (const dl_list list, const void ∗data)

  Finds the index of the specified data in a list.
- dl_list_itr dl_list_find_itr (const dl_list list, const void ∗data)

  Gets an iterator to the specified data in a list.
- void ∗ dl_list_data (const dl_list list, const size_t index)

  Returns a pointer to the data at a specified index.
- dl_list_itr dl_list_first (const dl_list list)

  Returns an iterator to the first element of a list.
- dl_list_itr dl_list_last (const dl_list list)

  Returns an iterator to the last element of a list.
- dl_list_itr dl_list_next (const dl_list_itr itr)

  Advances a list iterator by one element.
- dl_list_itr dl_list_prev (const dl_list_itr itr)

  Backs up a list iterator by one element.
- dl_list_itr dl_list_itr_from_index (const dl_list list, const size_t index)

  Return an iterator to a specified element of a list.
- void dl_list_lock (dl_list list)

  Locks a list's mutex.
- void dl_list_unlock (dl_list list)

  Unlocks a list's mutex.

4.8.1 Detailed Description

User interface to doubly linked list data structure.

Author

Paul Griffiths

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4.8.2 Function Documentation

4.8.2.1 void dl_list_append (dl_list *list,* void ∗ *data*)

Inserts an element at the end of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.8.2.2 void∗ dl_list_data (const **dl_list** *list*, const size_t *index*)

Returns a pointer to the data at a specified index.

Parameters

list	A pointer to the list.
index	The index of the data.

Returns

A pointer to the data, or NULL if the index is out of range.

4.8.2.3 int dl_list_delete_at (**dl_list** *list*, const size_t *index*)

Deletes a list element at a specified index.

Parameters

list	A pointer to the list.
index	The index of the element to delete.

Returns

0 on success, CDSERR_OUTOFRANGE if the the index is out of range.

4.8.2.4 int dl_list_find_index (const **dl_list** *list*, const void ∗ *data*)

Finds the index of the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

The index of the element, if found, or CDSERR_NOTFOUND if it is not in the list.

4.8.2.5 **dl_list_itr** dl_list_find_itr (const **dl_list** *list*, const void ∗ *data*)

Gets an iterator to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

An iterator to the found element, or NULL is the element is not in the list.

4.8.2.6 dl_list_itr dl_list_first (const dl_list *list*)

Returns an iterator to the first element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.8.2.7 void dl_list_free (dl_list *list*)

Frees the resources associated with a list.

Parameters

list	A pointer to the list to free.

4.8.2.8 dl_list dl_list_init (int(∗)(const void ∗, const void ∗) *cfunc,* void(∗)(void ∗) *free_func*)

Initializes a new doubly linked list.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a function to free a node. The function should return no value, and accept a `void` pointer to the node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new list.

4.8.2.9 int dl_list_insert_after (dl_list *list,* const dl_list_itr *itr,* void ∗ *data*)

Inserts an element after a provided iterator.

Note that dl_list_first() may return a NULL iterator when the list is empty. One reasonable behavior for this function would be to add a new node to the list in that case. However, an iterator may also become NULL when advanced to the end of the list. One possible way to modify this function would be to check the length of this list when the iterator is NULL, and if it is zero, add the first node to the list. However, the semantic meaning of adding an element *after* an iterator breaks down if that that iterator does not point to an existing element. Therefore, it is simpler for this function to simply refuse to handle NULL iterators. It is unlikely a user would want to call this function unless there are already elements in a list, and a valid iterator has been returned, e.g. through a find function.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.8.2.10 int dl_list_insert_at (**dl_list** *list,* const size_t *index,* void ∗ *data*)

Inserts an element at the specified index of a list.

Parameters

list	A pointer to the list.
index	The index at which to insert. Setting this equal to the length of the list (i.e. to one element past the zero-based index of the last element) inserts the element at the end of the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_OUTOFRANGE if `index` exceeds the length of the list.

4.8.2.11 int dl_list_insert_before (**dl_list** *list,* const **dl_list_itr** *itr,* void ∗ *data*)

Inserts an element before a provided iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.8.2.12 bool dl_list_isempty (const **dl_list** *list*)

Checks if a list is empty.

Parameters

list	A pointer to the list.

Returns

`true` if the list is empty, otherwise `false`.

4.8.2.13 **dl_list_itr** dl_list_itr_from_index (const **dl_list** *list,* const size_t *index*)

Return an iterator to a specified element of a list.

Parameters

list	A pointer to the list.
index	The specified index.

Returns

The iterator, or NULL if `index` is out of range.

4.8.2.14 dl_list_itr dl_list_last (const dl_list *list*)

Returns an iterator to the last element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.8.2.15 size_t dl_list_length (const dl_list *list*)

Returns the number of elements in a list.

Parameters

list	A pointer to the list.

4.8.2.16 void dl_list_lock (dl_list *list*)

Locks a list's mutex.

Parameters

list	A pointer to the list.

4.8.2.17 dl_list_itr dl_list_next (const dl_list_itr *itr*)

Advances a list iterator by one element.

Parameters

itr	The iterator to advance

Returns

The advanced iterator.

4.8.2.18 void dl_list_prepend (dl_list *list,* void ∗ *data*)

Inserts an element at the beginning of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.8.2.19 dl_list_itr dl_list_prev (const dl_list_itr *itr*)

Backs up a list iterator by one element.

Parameters

itr	The iterator to back up.

Returns

The backed up iterator.

4.8.2.20 void dl_list_unlock (dl_list *list*)

Unlocks a list's mutex.

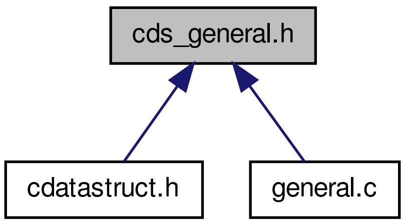
Parameters

list	A pointer to the list.

4.9 cds_general.h File Reference

Interface to general data structure helper functions.

This graph shows which files directly or indirectly include this file:



Functions

- void ∗ cds_new_int (const int n)

    Dynamically allocates memory for a new `int`*.*
- void ∗ cds_new_uint (const unsigned int n)

    Dynamically allocates memory for a new `unsigned int`*.*
- void ∗ cds_new_long (const long n)

    Dynamically allocates memory for a new `long`*.*
- void ∗ cds_new_ulong (const unsigned long n)

    Dynamically allocates memory for a new `unsigned long`*.*
- void ∗ cds_new_longlong (const long long n)

    Dynamically allocates memory for a new `long long`*.*

- void ∗ cds_new_ulonglong (const unsigned long long n)

  Allocates memory for a new `unsigned long long`.
- void ∗ cds_new_float (const float n)

  Dynamically allocates memory for a new `float`.
- void ∗ cds_new_double (const double n)

  Dynamically allocates memory for a new `double`.
- void ∗ cds_new_string (const char ∗str)

  Dynamically allocates memory for a new string.
- int cds_compare_int (const void ∗data, const void ∗cmp)

  Compares two `int` via `void` pointers.
- int cds_compare_uint (const void ∗data, const void ∗cmp)

  Compares two `unsigned int` via `void` pointers.
- int cds_compare_long (const void ∗data, const void ∗cmp)

  Compares two `long` via `void` pointers.
- int cds_compare_ulong (const void ∗data, const void ∗cmp)

  Compares two `unsigned long` via `void` pointers.
- int cds_compare_longlong (const void ∗data, const void ∗cmp)

  Compares two `long long` via `void` pointers.
- int cds_compare_ulonglong (const void ∗data, const void ∗cmp)

  Compares two `unsigned long long` via `void` pointers.
- int cds_compare_float (const void ∗data, const void ∗cmp)

  Compares two `float` via `void` pointers.
- int cds_compare_double (const void ∗data, const void ∗cmp)

  Compares two `double` via `void` pointers.
- int cds_compare_string (const void ∗data, const void ∗cmp)

  Compares two strings via `void` pointers.

4.9.1 Detailed Description

Interface to general data structure helper functions. Interface to general data structure helper functions.

Author

Paul Griffiths

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4.9.2 Function Documentation

4.9.2.1 int cds_compare_double (const void ∗ *data,* const void ∗ *cmp*)

Compares two `double` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.2 int cds_compare_float (const void ∗ *data,* const void ∗ *cmp*)

Compares two `float` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.3 int cds_compare_int (const void ∗ *data,* const void ∗ *cmp*)

Compares two `int` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.4 int cds_compare_long (const void ∗ *data,* const void ∗ *cmp*)

Compares two `long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.5 int cds_compare_longlong (const void ∗ *data,* const void ∗ *cmp*)

Compares two `long long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.6 int cds_compare_string (const void ∗ *data*, const void ∗ *cmp*)

Compares two strings via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.7 int cds_compare_uint (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned int` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.8 int cds_compare_ulong (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.9 int cds_compare_ulonglong (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned long long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.9.2.10 void∗ cds_new_double (const double *f*)

Dynamically allocates memory for a new `double`.

Parameters

f	The new `double` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.11 void∗ cds_new_float (const float *f*)

Dynamically allocates memory for a new `float`.

Parameters

f	The new `float` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.12 void∗ cds_new_int (const int *n*)

Dynamically allocates memory for a new `int`.

Parameters

n	The new `int` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.13 void∗ cds_new_long (const long *n*)

Dynamically allocates memory for a new `long`.

Parameters

n	The new `long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.14 void∗ cds_new_longlong (const long long *n*)

Dynamically allocates memory for a new `long long`.

Parameters

n	The new `long long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.15 void∗ cds_new_string (const char ∗ *str*)

Dynamically allocates memory for a new string.

Parameters

str	The new string for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.16 void∗ cds_new_uint (const unsigned int *n*)

Dynamically allocates memory for a new `unsigned int`.

Parameters

n	The new `unsigned int` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.17 void∗ cds_new_ulong (const unsigned long *n*)

Dynamically allocates memory for a new `unsigned long`.

Parameters

n	The new `unsigned long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.9.2.18 void∗ cds_new_ulonglong (const unsigned long long *n*)

Allocates memory for a new `unsigned long long`.

Parameters

n	The new `unsigned long long` for which to allocate.

Returns

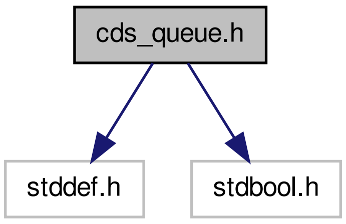
A `void` pointer to the allocated memory.

4.10 cds_queue.h File Reference

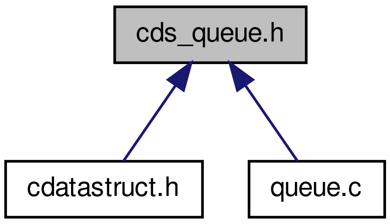
User interface to queue data structure.

```
#include <stddef.h>
#include <stdbool.h>
```

Include dependency graph for cds_queue.h:



This graph shows which files directly or indirectly include this file:



Typedefs

- typedef struct dl_list_t ∗ queue

    Typedef for queue pointer.

Functions

- queue queue_init (void(∗free_func)(void ∗))

Initializes a new queue.
- void queue_free (queue que)

  Frees memory and releases resources used by a queue.
- size_t queue_length (const queue que)

  Gets the number of items in a queue.
- bool queue_isempty (const queue que)

  Checks if a queue is empty.
- void ∗ queue_pop (queue que)

  Pops a data item from the queue.
- void queue_pushback (queue que, void ∗data)

  Pushes a data item onto the back of the queue.
- void queue_lock (queue que)

  Locks a queue's mutex.
- void queue_unlock (queue que)

  Unlocks a queue's mutex.

4.10.1 Detailed Description

User interface to queue data structure.

Author

Paul Griffiths

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4.10.2 Function Documentation

4.10.2.1 void queue_free (queue *que*)

Frees memory and releases resources used by a queue.

Parameters

que	A pointer to the queue.

4.10.2.2 queue queue_init (void(∗)(void ∗) *free_func*)

Initializes a new queue.

Parameters

free_func	A pointer to a function to free a queue node. The function should return no value, and accept a `void` pointer to a node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new queue.

4.10.2.3 bool queue_isempty (const queue *que*)

Checks if a queue is empty.

Parameters

que	A pointer to the queue.

Returns

`true` is the queue is empty, `false` if not.

4.10.2.4 size_t queue_length (const queue *que*)

Gets the number of items in a queue.

Parameters

que	A pointer to the queue.

Returns

The number of items in the queue.

4.10.2.5 void queue_lock (queue *que*)

Locks a queue's mutex.

Parameters

que	A pointer to the queue.

4.10.2.6 void* queue_pop (queue *que*)

Pops a data item from the queue.

The item returned was previously allocated using `malloc()`, so the user must `free()` the returned pointer when done.

Parameters

que	A pointer to the queue.

Returns

A `void` pointer to the popped data item.

4.10.2.7 void queue_pushback (queue *que,* void * *data*)

Pushes a data item onto the back of the queue.

The provided pointer should point to dynamically allocated memory.

Parameters

que	A pointer to the queue.
data	A pointer to the data item to be pushed.

4.10.2.8 void queue_unlock (**queue** *que*)

Unlocks a queue's mutex.

Parameters

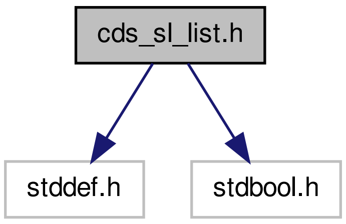
que	A pointer to the queue.

4.11 cds_sl_list.h File Reference

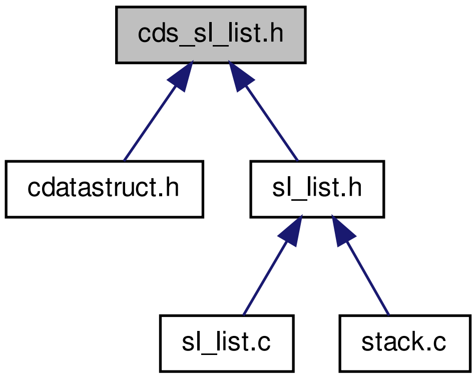
User interface to singly linked list data structure.

```
#include <stddef.h>
#include <stdbool.h>
```

Include dependency graph for cds_sl_list.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct sl_list_node_t

  Struct for singly linked list node.

Typedefs

- typedef struct sl_list_node_t sl_list_node_t

  Struct for singly linked list node.
- typedef struct sl_list_t ∗ sl_list

  Typedef for list pointer.
- typedef struct sl_list_node_t ∗ sl_list_itr

  Typedef for list iterator.

Functions

- sl_list sl_list_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

  Initializes a new singly linked list.
- void sl_list_free (sl_list list)

  Frees the resources associated with a list.
- size_t sl_list_length (const sl_list list)

  Returns the number of elements in a list.
- bool sl_list_isempty (const sl_list list)

  Checks if a list is empty.
- void sl_list_prepend (sl_list list, void ∗data)

  Inserts an element at the beginning of a list.
- int sl_list_insert_at (sl_list list, const size_t index, void ∗data)

  Inserts an element at the specified index of a list.
- int sl_list_insert_after (sl_list list, const sl_list_itr itr, void ∗data)

  Inserts an element after a provided iterator.

- int sl_list_delete_at (sl_list list, const size_t index)

  Deletes a list element at a specified index.
- int sl_list_find_index (const sl_list list, const void ∗data)

  Gets an index to the specified data in a list.
- sl_list_itr sl_list_find_itr (const sl_list list, const void ∗data)

  Gets an iterator to the specified data in a list.
- void ∗ sl_list_data (const sl_list list, const size_t index)

  Returns a pointer to the data at a specified index.
- sl_list_itr sl_list_first (const sl_list list)

  Returns an iterator to the first element of a list.
- sl_list_itr sl_list_next (const sl_list_itr itr)

  Advances a list iterator by one element.
- sl_list_itr sl_list_itr_from_index (const sl_list list, const size_t index)

  Return an iterator to a specified element of a list.
- void sl_list_lock (sl_list list)

  Locks a list's mutex.
- void sl_list_unlock (sl_list list)

  Unlocks a list's mutex.

4.11.1 Detailed Description

User interface to singly linked list data structure.

Author

Paul Griffiths

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4.11.2 Function Documentation

4.11.2.1 void∗ sl_list_data (const sl_list *list*, const size_t *index*)

Returns a pointer to the data at a specified index.

Parameters

list	A pointer to the list.
index	The index of the data.

Returns

A pointer to the data, or NULL if the index is out of range.

4.11.2.2 int sl_list_delete_at (sl_list *list*, const size_t *index*)

Deletes a list element at a specified index.

Parameters

list	A pointer to the list.
index	The index of the element to delete.

Returns

0 on success, CDSERR_OUTOFRANGE if the the index is out of range.

4.11.2.3 int sl_list_find_index (const sl_list *list*, const void ∗ *data*)

Gets an index to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

The index of the found element, or CDSERR_NOTFOUND if the element is not in the list.

4.11.2.4 sl_list_itr sl_list_find_itr (const sl_list *list*, const void ∗ *data*)

Gets an iterator to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

An iterator to the found element, or NULL is the element is not in the list.

4.11.2.5 sl_list_itr sl_list_first (const sl_list *list*)

Returns an iterator to the first element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.11.2.6 void sl_list_free (sl_list *list*)

Frees the resources associated with a list.

Parameters

list	A pointer to the list to free.

4.11.2.7 **sl_list** sl_list_init (int(∗)(const void ∗, const void ∗) *cfunc*, void(∗)(void ∗) *free_func*)

Initializes a new singly linked list.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a function for freeing a node. The function should return no value, and accept a `void` pointer to the node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new list.

4.11.2.8 int sl_list_insert_after (**sl_list** *list*, const **sl_list_itr** *itr*, void ∗ *data*)

Inserts an element after a provided iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.11.2.9 int sl_list_insert_at (**sl_list** *list*, const size_t *index*, void ∗ *data*)

Inserts an element at the specified index of a list.

Parameters

list	A pointer to the list.
index	The index at which to insert. Setting this equal to the length of the list (i.e. to one element past the zero-based index of the last element) inserts the element at the end of the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_OUTOFRANGE if `index` exceeds the length of the list.

4.11.2.10 bool sl_list_isempty (const **sl_list** *list*)

Checks if a list is empty.

Parameters

list	A pointer to the list.

Returns

`true` if the list is empty, otherwise `false`.

4.11.2.11 sl_list_itr sl_list_itr_from_index (const sl_list *list*, const size_t *index*)

Return an iterator to a specified element of a list.

Parameters

list	A pointer to the list.
index	The specified index.

Returns

The iterator, or NULL if `index` is out of range.

4.11.2.12 size_t sl_list_length (const sl_list *list*)

Returns the number of elements in a list.

Parameters

list	A pointer to the list.

4.11.2.13 void sl_list_lock (sl_list *list*)

Locks a list's mutex.

Parameters

list	A pointer to the list.

4.11.2.14 sl_list_itr sl_list_next (const sl_list_itr *itr*)

Advances a list iterator by one element.

Parameters

itr	The iterator to advance

Returns

The advanced iterator.

4.11.2.15 void sl_list_prepend (sl_list *list*, void ∗ *data*)

Inserts an element at the beginning of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.11.2.16 void sl_list_unlock (**sl_list** *list*)

Unlocks a list's mutex.

Parameters

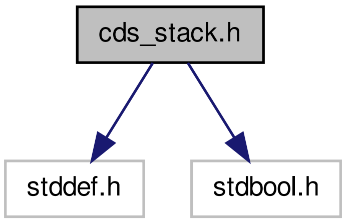
list	A pointer to the list.

4.12 cds_stack.h File Reference

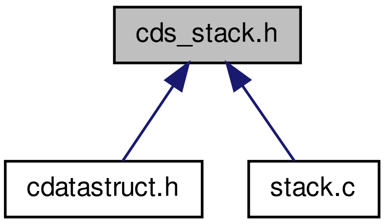
User interface to stack data structure.

```
#include <stddef.h>
#include <stdbool.h>
```

Include dependency graph for cds_stack.h:



This graph shows which files directly or indirectly include this file:



Typedefs

- typedef struct sl_list_t ∗ stack

    Typedef for stack pointer.

Functions

- stack stack_init (void(∗free_func)(void ∗))

    Initializes a new stack.
- void stack_free (stack stk)

    Frees memory and releases resources used by a stack.
- size_t stack_length (const stack stk)

    Gets the number of items in a stack.
- bool stack_isempty (const stack stk)

    Checks if a stack is empty.
- void ∗ stack_pop (stack stk)

    Pops a data item from the stack.
- void stack_push (stack stk, void ∗data)

    Pushes a data item onto the stack.
- void stack_lock (stack stk)

    Locks a stack's mutex.
- void stack_unlock (stack stk)

    Unlocks a stack's mutex.

4.12.1 Detailed Description

User interface to stack data structure.

Author

Paul Griffiths

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4.12.2 Function Documentation

4.12.2.1 void stack_free (stack *stk*)

Frees memory and releases resources used by a stack.

Parameters

stk	A pointer to the stack.

4.12.2.2 stack stack_init (void(∗)(void ∗) *free_func*)

Initializes a new stack.

Parameters

free_func	A pointer to a function a free a stack node. The function should return no value, and accept a `void` pointer to a node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new stack.

4.12.2.3 bool stack_isempty (const stack *stk*)

Checks if a stack is empty.

Parameters

stk	A pointer to the stack.

Returns

`true` is the stack is empty, `false` if not.

4.12.2.4 size_t stack_length (const stack *stk*)

Gets the number of items in a stack.

Parameters

stk	A pointer to the stack.

Returns

The number of items in the stack.

4.12.2.5 void stack_lock (stack *stk*)

Locks a stack's mutex.

Parameters

stk	A pointer to the stack.

4.12.2.6 void∗ stack_pop (stack *stk*)

Pops a data item from the stack.

The item returned was previously allocated using `malloc()`, so the user must `free()` the returned pointer when done.

Parameters

stk	A pointer to the stack.

Returns

A `void` pointer to the popped data item.

4.12.2.7 void stack_push (stack *stk*, void ∗ *data*)

Pushes a data item onto the stack.

The provided pointer should point to dynamically allocated memory.

Parameters

stk	A pointer to the stack.
data	A pointer to the data item to be pushed.

4.12.2.8 void stack_unlock (stack *stk*)

Unlocks a stack's mutex.

Parameters

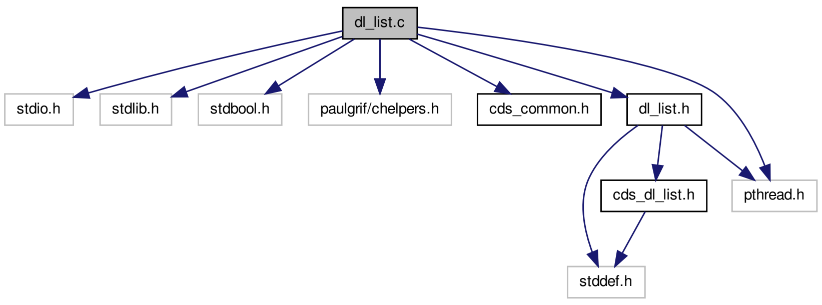
stk	A pointer to the stack.

4.13 dl_list.c File Reference

Implementation of doubly linked list data structure.

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <paulgrif/chelpers.h>
#include "cds_common.h"
#include "dl_list.h"
#include <pthread.h>
```

Include dependency graph for dl_list.c:



Functions

- dl_list dl_list_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

  Initializes a new doubly linked list.

- void dl_list_free (dl_list list)

    Frees the resources associated with a list.
- size_t dl_list_length (const dl_list list)

    Returns the number of elements in a list.
- bool dl_list_isempty (const dl_list list)

    Checks if a list is empty.
- void dl_list_prepend (dl_list list, void ∗data)

    Inserts an element at the beginning of a list.
- void dl_list_append (dl_list list, void ∗data)

    Inserts an element at the end of a list.
- int dl_list_insert_before (dl_list list, const dl_list_itr itr, void ∗data)

    Inserts an element before a provided iterator.
- int dl_list_insert_at (dl_list list, const size_t index, void ∗data)

    Inserts an element at the specified index of a list.
- int dl_list_insert_after (dl_list list, const dl_list_itr itr, void ∗data)

    Inserts an element after a provided iterator.
- int dl_list_delete_at (dl_list list, const size_t index)

    Deletes a list element at a specified index.
- int dl_list_find_index (const dl_list list, const void ∗data)

    Finds the index of the specified data in a list.
- dl_list_itr dl_list_find_itr (const dl_list list, const void ∗data)

    Gets an iterator to the specified data in a list.
- void ∗ dl_list_data (const dl_list list, const size_t index)

    Returns a pointer to the data at a specified index.
- dl_list_itr dl_list_first (const dl_list list)

    Returns an iterator to the first element of a list.
- dl_list_itr dl_list_last (const dl_list list)

    Returns an iterator to the last element of a list.
- dl_list_itr dl_list_next (const dl_list_itr itr)

    Advances a list iterator by one element.
- dl_list_itr dl_list_prev (const dl_list_itr itr)

    Backs up a list iterator by one element.
- dl_list_itr dl_list_itr_from_index (const dl_list list, const size_t index)

    Return an iterator to a specified element of a list.
- dl_list_node dl_list_new_node (void ∗data)

    Creates a new list node.
- void dl_list_free_node (dl_list list, dl_list_node node)

    Frees resources for a node and any data.
- void dl_list_insert_node_front (dl_list list, dl_list_node node)

    Inserts a node at the front of a list.
- void dl_list_insert_node_before_mid (dl_list list, dl_list_itr itr, dl_list_node node)

    Inserts a node in the middle of a list before a specified iterator.
- void dl_list_insert_node_after_mid (dl_list list, dl_list_itr itr, dl_list_node node)

    Inserts a node in the middle of a list after a specified iterator.
- void dl_list_insert_node_back (dl_list list, dl_list_node node)

    Inserts a node at the back of a list.
- dl_list_node dl_list_remove_at (dl_list list, const size_t index)

    Removes, but does not delete, an element at an index.
- dl_list_node dl_list_remove_node_front (dl_list list)

    Removes the first node of a list.
- dl_list_node dl_list_remove_node_mid (dl_list list, dl_list_node node)

Removes a specifed node from the middle of a list.

- dl_list_node dl_list_remove_node_back (dl_list list)

  Removes the last node of a list.
- void dl_list_find (const dl_list list, const void ∗data, dl_list_itr ∗p_itr, int ∗p_index)

  Finds the index of, and a pointer to, the first node in the list containing the specified data.
- void dl_list_lock (dl_list list)

  Locks a list's mutex.
- void dl_list_unlock (dl_list list)

  Unlocks a list's mutex.

4.13.1 Detailed Description

Implementation of doubly linked list data structure.

Author

Paul Griffiths

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4.13.2 Function Documentation

4.13.2.1 void dl_list_append (**dl_list** *list,* void ∗ *data*)

Inserts an element at the end of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.13.2.2 void∗ dl_list_data (const **dl_list** *list,* const size_t *index*)

Returns a pointer to the data at a specified index.

Parameters

list	A pointer to the list.
index	The index of the data.

Returns

A pointer to the data, or NULL if the index is out of range.

4.13.2.3 int dl_list_delete_at (**dl_list** *list,* const size_t *index*)

Deletes a list element at a specified index.

Parameters

list	A pointer to the list.
index	The index of the element to delete.

Returns

0 on success, CDSERR_OUTOFRANGE if the the index is out of range.

4.13.2.4 void dl_list_find (const dl_list *list,* const void ∗ *data,* dl_list_itr ∗ *p_itr,* int ∗ *p_index*)

Finds the index of, and a pointer to, the first node in the list containing the specified data.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.
p_itr	A pointer to an iterator to populate with the result. This is set to CDSERR_NOTFOUND if the data was not found.
p_index	A pointer to an integer the populate with the result. This is set to NULL if the data was not found.

4.13.2.5 int dl_list_find_index (const dl_list *list,* const void ∗ *data*)

Finds the index of the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

The index of the element, if found, or CDSERR_NOTFOUND if it is not in the list.

4.13.2.6 dl_list_itr dl_list_find_itr (const dl_list *list,* const void ∗ *data*)

Gets an iterator to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

An iterator to the found element, or NULL is the element is not in the list.

4.13.2.7 dl_list_itr dl_list_first (const dl_list *list*)

Returns an iterator to the first element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.13.2.8 void dl_list_free (**dl_list** *list*)

Frees the resources associated with a list.

Parameters

list	A pointer to the list to free.

4.13.2.9 void dl_list_free_node (**dl_list** *list,* **dl_list_node** *node*)

Frees resources for a node and any data.

Parameters

list	A pointer to the list.
node	A pointer to the node to free.

4.13.2.10 **dl_list** dl_list_init (int(∗)(const void ∗, const void ∗) *cfunc,* void(∗)(void ∗) *free_func*)

Initializes a new doubly linked list.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a function to free a node. The function should return no value, and accept a `void` pointer to the node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new list.

4.13.2.11 int dl_list_insert_after (**dl_list** *list,* const **dl_list_itr** *itr,* void ∗ *data*)

Inserts an element after a provided iterator.

Note that dl_list_first() may return a NULL iterator when the list is empty. One reasonable behavior for this function would be to add a new node to the list in that case. However, an iterator may also become NULL when advanced to the end of the list. One possible way to modify this function would be to check the length of this list when the iterator is NULL, and if it is zero, add the first node to the list. However, the semantic meaning of adding an element *after* an iterator breaks down if that that iterator does not point to an existing element. Therefore, it is simpler for this function to simply refuse to handle NULL iterators. It is unlikely a user would want to call this function unless there are already elements in a list, and a valid iterator has been returned, e.g. through a find function.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.13.2.12 int dl_list_insert_at (dl_list *list*, const size_t *index*, void * *data*)

Inserts an element at the specified index of a list.

Parameters

list	A pointer to the list.
index	The index at which to insert. Setting this equal to the length of the list (i.e. to one element past the zero-based index of the last element) inserts the element at the end of the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_OUTOFRANGE if `index` exceeds the length of the list.

4.13.2.13 int dl_list_insert_before (dl_list *list*, const dl_list_itr *itr*, void * *data*)

Inserts an element before a provided iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.13.2.14 void dl_list_insert_node_after_mid (dl_list *list*, dl_list_itr *itr*, dl_list_node *node*)

Inserts a node in the middle of a list after a specified iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert. As this is inserting in the middle, this iterator should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.
node	A pointer to the node to insert.

4.13.2.15 void dl_list_insert_node_back (**dl_list** *list,* **dl_list_node** *node*)

Inserts a node at the back of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to insert.

4.13.2.16 void dl_list_insert_node_before_mid (**dl_list** *list,* **dl_list_itr** *itr,* **dl_list_node** *node*)

Inserts a node in the middle of a list before a specified iterator.

Parameters

list	A pointer to the list.
itr	The iterator before which to insert. As this is inserting in the middle, this iterator should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.
node	A pointer to the node to insert.

4.13.2.17 void dl_list_insert_node_front (**dl_list** *list,* **dl_list_node** *node*)

Inserts a node at the front of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to insert.

4.13.2.18 bool dl_list_isempty (const **dl_list** *list*)

Checks if a list is empty.

Parameters

list	A pointer to the list.

Returns

`true` if the list is empty, otherwise `false`.

4.13.2.19 **dl_list_itr** dl_list_itr_from_index (const **dl_list** *list,* const size_t *index*)

Return an iterator to a specified element of a list.

Parameters

list	A pointer to the list.
index	The specified index.

Returns

The iterator, or NULL if `index` is out of range.

4.13.2.20 dl_list_itr dl_list_last (const dl_list *list*)

Returns an iterator to the last element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.13.2.21 size_t dl_list_length (const dl_list *list*)

Returns the number of elements in a list.

Parameters

list	A pointer to the list.

4.13.2.22 void dl_list_lock (dl_list *list*)

Locks a list's mutex.

Parameters

list	A pointer to the list.

4.13.2.23 dl_list_node dl_list_new_node (void ∗ *data*)

Creates a new list node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly created node.

4.13.2.24 dl_list_itr dl_list_next (const dl_list_itr *itr*)

Advances a list iterator by one element.

Parameters

itr	The iterator to advance

Returns

The advanced iterator.

4.13.2.25 void dl_list_prepend (dl_list *list,* void $*$ *data*)

Inserts an element at the beginning of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.13.2.26 dl_list_itr dl_list_prev (const dl_list_itr *itr*)

Backs up a list iterator by one element.

Parameters

itr	The iterator to back up.

Returns

The backed up iterator.

4.13.2.27 dl_list_node dl_list_remove_at (dl_list *list,* const size_t *index*)

Removes, but does not delete, an element at an index.

Parameters

list	A pointer to the list.
index	The index of the element to be removed.

Returns

A pointer to the removed node. This should be `free()`d by calling dl_list_free_node().

4.13.2.28 dl_list_node dl_list_remove_node_back (dl_list *list*)

Removes the last node of a list.

Parameters

list	A pointer to the list.

Returns

A pointer to the removed node.

4.13.2.29 dl_list_node dl_list_remove_node_front (dl_list *list*)

Removes the first node of a list.

Parameters

list	A pointer to the list.

Returns

A pointer to the removed node.

4.13.2.30 dl_list_node dl_list_remove_node_mid (dl_list *list,* dl_list_node *node*)

Removes a specifed node from the middle of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to remove. As this is removing from the middle, this node should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.

Returns

A pointer to the removed node, i.e. equal to `itr`.

4.13.2.31 void dl_list_unlock (dl_list *list*)

Unlocks a list's mutex.

Parameters

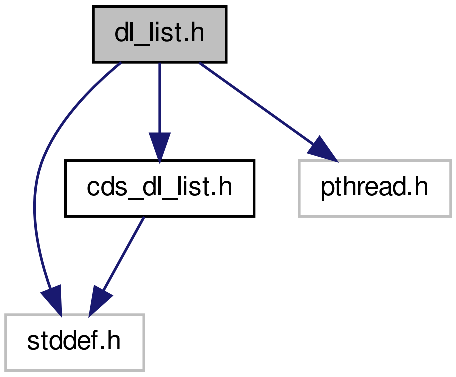
list	A pointer to the list.

4.14 dl_list.h File Reference

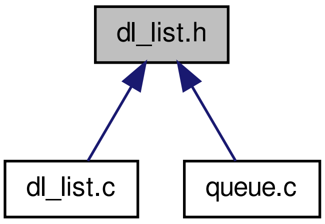
Developer interface to double linked list data structure.

```
#include <stddef.h>
#include "cds_dl_list.h"
#include <pthread.h>
```

Include dependency graph for dl_list.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct dl_list_t

  Struct to contain a list.

Macros

- #define _POSIX_C_SOURCE 200809L

  Enable POSIX library.

Typedefs

- typedef struct dl_list_t dl_list_t

  Struct to contain a list.
- typedef struct dl_list_node_t $*$ dl_list_node

  Typedef for list node.

Functions

- dl_list_node dl_list_new_node (void ∗data)

  Creates a new list node.
- void dl_list_free_node (dl_list list, dl_list_node node)

  Frees resources for a node and any data.
- void dl_list_insert_node_front (dl_list list, dl_list_node node)

  Inserts a node at the front of a list.
- void dl_list_insert_node_before_mid (dl_list list, dl_list_itr itr, dl_list_node node)

  Inserts a node in the middle of a list before a specified iterator.
- void dl_list_insert_node_after_mid (dl_list list, dl_list_itr itr, dl_list_node node)

  Inserts a node in the middle of a list after a specified iterator.
- void dl_list_insert_node_back (dl_list list, dl_list_node node)

  Inserts a node at the back of a list.
- dl_list_node dl_list_remove_at (dl_list list, const size_t index)

  Removes, but does not delete, an element at an index.
- dl_list_node dl_list_remove_node_front (dl_list list)

  Removes the first node of a list.
- dl_list_node dl_list_remove_node_mid (dl_list list, dl_list_itr itr)

  Removes a specifed node from the middle of a list.
- dl_list_node dl_list_remove_node_back (dl_list list)

  Removes the last node of a list.
- void dl_list_find (const dl_list list, const void ∗data, dl_list_itr ∗p_itr, int ∗p_index)

  Finds the index of, and a pointer to, the first node in the list containing the specified data.

4.14.1 Detailed Description

Developer interface to double linked list data structure.

Author

Paul Griffiths

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4.14.2 Function Documentation

4.14.2.1 void dl_list_find (const **dl_list** *list,* const void ∗ *data,* **dl_list_itr** ∗ *p_itr,* int ∗ *p_index*)

Finds the index of, and a pointer to, the first node in the list containing the specified data.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.
p_itr	A pointer to an iterator to populate with the result. This is set to CDSERR_NOTFOUND if the data was not found.
p_index	A pointer to an integer the populate with the result. This is set to NULL if the data was not found.

4.14.2.2 void dl_list_free_node (**dl_list** *list*, **dl_list_node** *node*)

Frees resources for a node and any data.

Parameters

list	A pointer to the list.
node	A pointer to the node to free.

4.14.2.3 void dl_list_insert_node_after_mid (**dl_list** *list*, **dl_list_itr** *itr*, **dl_list_node** *node*)

Inserts a node in the middle of a list after a specified iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert. As this is inserting in the middle, this iterator should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.
node	A pointer to the node to insert.

4.14.2.4 void dl_list_insert_node_back (**dl_list** *list*, **dl_list_node** *node*)

Inserts a node at the back of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to insert.

4.14.2.5 void dl_list_insert_node_before_mid (**dl_list** *list*, **dl_list_itr** *itr*, **dl_list_node** *node*)

Inserts a node in the middle of a list before a specified iterator.

Parameters

list	A pointer to the list.
itr	The iterator before which to insert. As this is inserting in the middle, this iterator should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.
node	A pointer to the node to insert.

4.14.2.6 void dl_list_insert_node_front (**dl_list** *list*, **dl_list_node** *node*)

Inserts a node at the front of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to insert.

4.14.2.7 dl_list_node dl_list_new_node (void * *data*)

Creates a new list node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly created node.

4.14.2.8 dl_list_node dl_list_remove_at (dl_list *list,* const size_t *index*)

Removes, but does not delete, an element at an index.

Parameters

list	A pointer to the list.
index	The index of the element to be removed.

Returns

A pointer to the removed node. This should be `free()`d by calling dl_list_free_node().

4.14.2.9 dl_list_node dl_list_remove_node_back (dl_list *list*)

Removes the last node of a list.

Parameters

list	A pointer to the list.

Returns

A pointer to the removed node.

4.14.2.10 dl_list_node dl_list_remove_node_front (dl_list *list*)

Removes the first node of a list.

Parameters

list	A pointer to the list.

Returns

A pointer to the removed node.

4.14.2.11 dl_list_node dl_list_remove_node_mid (dl_list *list,* dl_list_node *node*)

Removes a specifed node from the middle of a list.

Parameters

list	A pointer to the list.
node	A pointer to the node to remove. As this is removing from the middle, this node should not be either the front or the back of the list, i.e. both the `prev` and `next` members should be non-NULL.

Returns

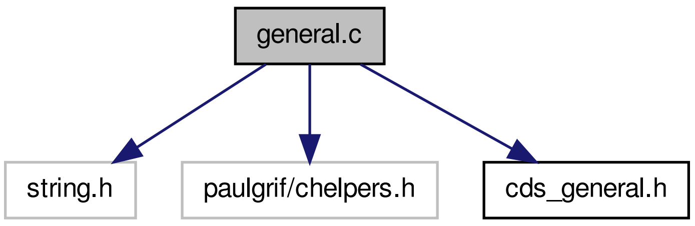
A pointer to the removed node, i.e. equal to `itr`.

4.15 general.c File Reference

Implementation of general data structure helper functions.

```
#include <string.h>
#include <paulgrif/chelpers.h>
#include "cds_general.h"
```

Include dependency graph for general.c:



Functions

- void ∗ cds_new_int (const int n)

  Dynamically allocates memory for a new `int`*.*
- void ∗ cds_new_uint (const unsigned int n)

  Dynamically allocates memory for a new `unsigned int`*.*
- void ∗ cds_new_long (const long n)

  Dynamically allocates memory for a new `long`*.*
- void ∗ cds_new_ulong (const unsigned long n)

  Dynamically allocates memory for a new `unsigned long`*.*
- void ∗ cds_new_longlong (const long long n)

  Dynamically allocates memory for a new `long long`*.*
- void ∗ cds_new_ulonglong (const unsigned long long n)

  Allocates memory for a new `unsigned long long`*.*
- void ∗ cds_new_float (const float f)

  Dynamically allocates memory for a new `float`*.*
- void ∗ cds_new_double (const double f)

  Dynamically allocates memory for a new `double`*.*
- void ∗ cds_new_string (const char ∗str)

Dynamically allocates memory for a new string.

- int cds_compare_int (const void ∗data, const void ∗cmp)

  Compares two `int` *via* `void` *pointers.*
- int cds_compare_uint (const void ∗data, const void ∗cmp)

  Compares two `unsigned int` *via* `void` *pointers.*
- int cds_compare_long (const void ∗data, const void ∗cmp)

  Compares two `long` *via* `void` *pointers.*
- int cds_compare_ulong (const void ∗data, const void ∗cmp)

  Compares two `unsigned long` *via* `void` *pointers.*
- int cds_compare_longlong (const void ∗data, const void ∗cmp)

  Compares two `long long` *via* `void` *pointers.*
- int cds_compare_ulonglong (const void ∗data, const void ∗cmp)

  Compares two `unsigned long long` *via* `void` *pointers.*
- int cds_compare_float (const void ∗data, const void ∗cmp)

  Compares two `float` *via* `void` *pointers.*
- int cds_compare_double (const void ∗data, const void ∗cmp)

  Compares two `double` *via* `void` *pointers.*
- int cds_compare_string (const void ∗data, const void ∗cmp)

  Compares two strings via `void` *pointers.*

4.15.1 Detailed Description

Implementation of general data structure helper functions. Implementation of general data structure helper functions.

Author

Paul Griffiths

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4.15.2 Function Documentation

4.15.2.1 int cds_compare_double (const void ∗ *data,* const void ∗ *cmp*)

Compares two `double` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.2 int cds_compare_float (const void ∗ *data,* const void ∗ *cmp*)

Compares two `float` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.3 int cds_compare_int (const void * *data*, const void * *cmp*)

Compares two `int` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.4 int cds_compare_long (const void * *data*, const void * *cmp*)

Compares two `long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.5 int cds_compare_longlong (const void * *data*, const void * *cmp*)

Compares two `long long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.6 int cds_compare_string (const void ∗ *data*, const void ∗ *cmp*)

Compares two strings via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.7 int cds_compare_uint (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned int` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.8 int cds_compare_ulong (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.9 int cds_compare_ulonglong (const void ∗ *data*, const void ∗ *cmp*)

Compares two `unsigned long long` via `void` pointers.

Parameters

data	Pointer to the data to which to compare.
cmp	Pointer to the comparison data.

Returns

-1 if the comparison data is greater than the data, 1 if the comparison data is less than the data, and 0 if the comparison data is equal to the data.

4.15.2.10 void∗ cds_new_double (const double *f*)

Dynamically allocates memory for a new `double`.

Parameters

f	The new `double` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.11 void∗ cds_new_float (const float *f*)

Dynamically allocates memory for a new `float`.

Parameters

f	The new `float` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.12 void∗ cds_new_int (const int *n*)

Dynamically allocates memory for a new `int`.

Parameters

n	The new `int` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.13 void∗ cds_new_long (const long *n*)

Dynamically allocates memory for a new `long`.

Parameters

n	The new `long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.14 void* cds_new_longlong (const long long *n*)

Dynamically allocates memory for a new `long long`.

Parameters

n	The new `long long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.15 void* cds_new_string (const char * *str*)

Dynamically allocates memory for a new string.

Parameters

str	The new string for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.16 void* cds_new_uint (const unsigned int *n*)

Dynamically allocates memory for a new `unsigned int`.

Parameters

n	The new `unsigned int` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.17 void* cds_new_ulong (const unsigned long *n*)

Dynamically allocates memory for a new `unsigned long`.

Parameters

n	The new `unsigned long` for which to allocate.

Returns

A `void` pointer to the allocated memory.

4.15.2.18 void* cds_new_ulonglong (const unsigned long long *n*)

Allocates memory for a new `unsigned long long`.

Parameters

n	The new `unsigned long long` for which to allocate.

Returns

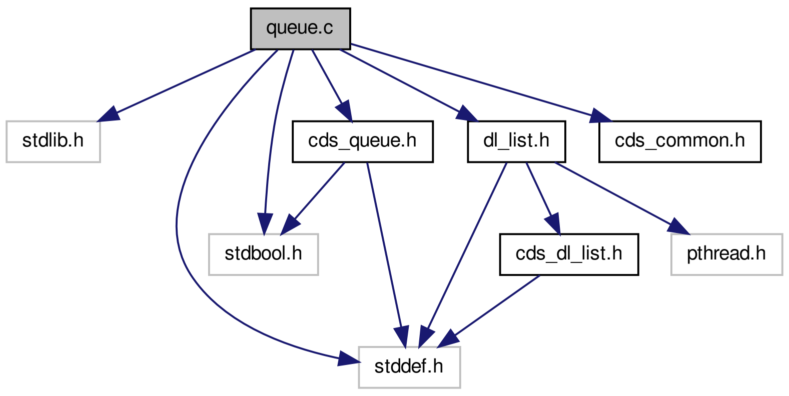
A `void` pointer to the allocated memory.

4.16 queue.c File Reference

Implementation of queue data structure.

```
#include <stdlib.h>
#include <stddef.h>
#include <stdbool.h>
#include "cds_queue.h"
#include "dl_list.h"
#include "cds_common.h"
```

Include dependency graph for queue.c:



Functions

- queue queue_init (void(∗free_func)(void ∗))

  Initializes a new queue.
- void queue_free (queue que)

  Frees memory and releases resources used by a queue.
- size_t queue_length (const queue que)

  Gets the number of items in a queue.
- bool queue_isempty (const queue que)

  Checks if a queue is empty.
- void ∗ queue_pop (queue que)

  Pops a data item from the queue.
- void queue_pushback (queue que, void ∗data)

  Pushes a data item onto the back of the queue.
- void queue_lock (queue que)

  Locks a queue's mutex.
- void queue_unlock (queue que)

  Unlocks a queue's mutex.

4.16.1 Detailed Description

Implementation of queue data structure. Implemented in terms of a doubly linked, double-ended list data structure.

Author

Paul Griffiths

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4.16.2 Function Documentation

4.16.2.1 void queue_free (**queue** *que*)

Frees memory and releases resources used by a queue.

Parameters

que	A pointer to the queue.

4.16.2.2 **queue** queue_init (void(∗)(void ∗) *free_func*)

Initializes a new queue.

Parameters

free_func	A pointer to a function to free a queue node. The function should return no value, and accept a `void` pointer to a node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new queue.

4.16.2.3 bool queue_isempty (const **queue** *que*)

Checks if a queue is empty.

Parameters

que	A pointer to the queue.

Returns

`true` is the queue is empty, `false` if not.

4.16.2.4 size_t queue_length (const **queue** *que*)

Gets the number of items in a queue.

Parameters

que	A pointer to the queue.

Returns

The number of items in the queue.

4.16.2.5 void queue_lock (queue *que*)

Locks a queue's mutex.

Parameters

que	A pointer to the queue.

4.16.2.6 void∗ queue_pop (queue *que*)

Pops a data item from the queue.

The item returned was previously allocated using `malloc()`, so the user must `free()` the returned pointer when done.

Parameters

que	A pointer to the queue.

Returns

A `void` pointer to the popped data item.

4.16.2.7 void queue_pushback (queue *que,* void ∗ *data*)

Pushes a data item onto the back of the queue.

The provided pointer should point to dynamically allocated memory.

Parameters

que	A pointer to the queue.
data	A pointer to the data item to be pushed.

4.16.2.8 void queue_unlock (queue *que*)

Unlocks a queue's mutex.

Parameters

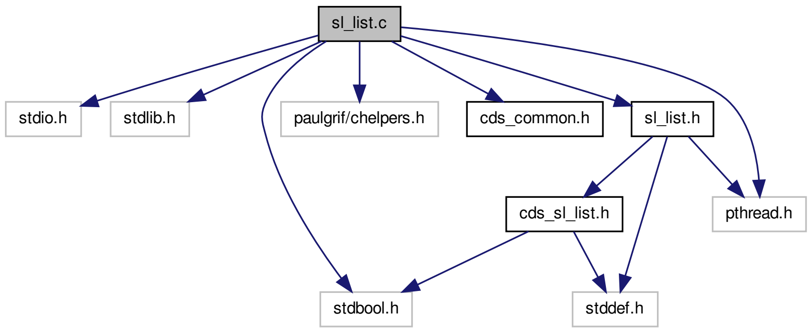
que	A pointer to the queue.

4.17 sl_list.c File Reference

Implementation of singly linked list data structure.

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <paulgrif/chelpers.h>
#include "cds_common.h"
#include "sl_list.h"
#include <pthread.h>
```

Include dependency graph for sl_list.c:



Functions

- sl_list sl_list_init (int(∗cfunc)(const void ∗, const void ∗), void(∗free_func)(void ∗))

    Initializes a new singly linked list.
- void sl_list_free (sl_list list)

    Frees the resources associated with a list.
- size_t sl_list_length (const sl_list list)

    Returns the number of elements in a list.
- bool sl_list_isempty (const sl_list list)

    Checks if a list is empty.
- void sl_list_prepend (sl_list list, void ∗data)

    Inserts an element at the beginning of a list.
- int sl_list_insert_at (sl_list list, const size_t index, void ∗data)

    Inserts an element at the specified index of a list.
- int sl_list_insert_after (sl_list list, const sl_list_itr itr, void ∗data)

    Inserts an element after a provided iterator.
- int sl_list_delete_at (sl_list list, const size_t index)

    Deletes a list element at a specified index.
- int sl_list_find_index (const sl_list list, const void ∗data)

    Gets an index to the specified data in a list.
- sl_list_itr sl_list_find_itr (const sl_list list, const void ∗data)

    Gets an iterator to the specified data in a list.
- void ∗ sl_list_data (const sl_list list, const size_t index)

    Returns a pointer to the data at a specified index.
- sl_list_itr sl_list_first (const sl_list list)

    Returns an iterator to the first element of a list.
- sl_list_itr sl_list_next (const sl_list_itr itr)

    Advances a list iterator by one element.

- sl_list_itr sl_list_itr_from_index (const sl_list list, const size_t index)

    Return an iterator to a specified element of a list.
- sl_list_node sl_list_new_node (void ∗data)

    Creates a new list node.
- void sl_list_free_node (sl_list list, sl_list_node node)

    Frees resources for a node and any data.
- sl_list_node sl_list_remove_at (sl_list list, const size_t index)

    Removes, but does not delete, an element at an index.
- void sl_list_find (const sl_list list, const void ∗data, sl_list_itr ∗p_itr, int ∗p_index)

    Gets an index and iterator to a specified piece of data.
- void sl_list_lock (sl_list list)

    Locks a list's mutex.
- void sl_list_unlock (sl_list list)

    Unlocks a list's mutex.

4.17.1 Detailed Description

Implementation of singly linked list data structure.

Author

Paul Griffiths

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4.17.2 Function Documentation

4.17.2.1 void∗ sl_list_data (const sl_list *list*, const size_t *index*)

Returns a pointer to the data at a specified index.

Parameters

list	A pointer to the list.
index	The index of the data.

Returns

A pointer to the data, or NULL if the index is out of range.

4.17.2.2 int sl_list_delete_at (sl_list *list*, const size_t *index*)

Deletes a list element at a specified index.

Parameters

list	A pointer to the list.
index	The index of the element to delete.

Returns

0 on success, CDSERR_OUTOFRANGE if the the index is out of range.

4.17.2.3 void sl_list_find (const **sl_list** *list,* const void ∗ *data,* **sl_list_itr** ∗ *p_itr,* int ∗ *p_index*)

Gets an index and iterator to a specified piece of data.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.
p_itr	A pointer to an iterator to populate with the result. This parameter is ignored if set to NULL.
p_index	A pointer to an integer index to populate with the result. This parameter is ignored if set to NULL.

4.17.2.4 int sl_list_find_index (const **sl_list** *list,* const void ∗ *data*)

Gets an index to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

The index of the found element, or CDSERR_NOTFOUND if the element is not in the list.

4.17.2.5 **sl_list_itr** sl_list_find_itr (const **sl_list** *list,* const void ∗ *data*)

Gets an iterator to the specified data in a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.

Returns

An iterator to the found element, or NULL is the element is not in the list.

4.17.2.6 **sl_list_itr** sl_list_first (const **sl_list** *list*)

Returns an iterator to the first element of a list.

Parameters

list	A pointer to the list.

Returns

An iterator to the first element.

4.17.2.7 void sl_list_free (**sl_list** *list*)

Frees the resources associated with a list.

Parameters

list	A pointer to the list to free.

4.17.2.8 void sl_list_free_node (**sl_list** *list,* **sl_list_node** *node*)

Frees resources for a node and any data.

Parameters

list	A pointer to the list.
node	A pointer to the node to free.

4.17.2.9 **sl_list** sl_list_init (int(∗)(const void ∗, const void ∗) *cfunc,* void(∗)(void ∗) *free_func*)

Initializes a new singly linked list.

Parameters

cfunc	A pointer to a compare function. The function should return `int` and accept two parameters of type `void *`. It should return less than 1 if the first parameter is less than the second, greater than 1 if the first parameter is greater than the second, and zero if the parameters are equal.
free_func	A pointer to a function for freeing a node. The function should return no value, and accept a `void` pointer to the node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new list.

4.17.2.10 int sl_list_insert_after (**sl_list** *list,* const **sl_list_itr** *itr,* void ∗ *data*)

Inserts an element after a provided iterator.

Parameters

list	A pointer to the list.
itr	The iterator after which to insert.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_BADITERATOR if `itr` is a NULL pointer.

4.17.2.11 int sl_list_insert_at (**sl_list** *list,* const size_t *index,* void ∗ *data*)

Inserts an element at the specified index of a list.

Parameters

list	A pointer to the list.
index	The index at which to insert. Setting this equal to the length of the list (i.e. to one element past the zero-based index of the last element) inserts the element at the end of the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

Returns

0 on success, CDSERR_OUTOFRANGE if `index` exceeds the length of the list.

4.17.2.12 bool sl_list_isempty (const sl_list *list*)

Checks if a list is empty.

Parameters

list	A pointer to the list.

Returns

`true` if the list is empty, otherwise `false`.

4.17.2.13 sl_list_itr sl_list_itr_from_index (const sl_list *list,* const size_t *index*)

Return an iterator to a specified element of a list.

Parameters

list	A pointer to the list.
index	The specified index.

Returns

The iterator, or NULL if `index` is out of range.

4.17.2.14 size_t sl_list_length (const sl_list *list*)

Returns the number of elements in a list.

Parameters

list	A pointer to the list.

4.17.2.15 void sl_list_lock (sl_list *list*)

Locks a list's mutex.

Parameters

list	A pointer to the list.

4.17.2.16 sl_list_node sl_list_new_node (void * *data*)

Creates a new list node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly created node.

4.17.2.17 sl_list_itr sl_list_next (const sl_list_itr *itr*)

Advances a list iterator by one element.

Parameters

itr	The iterator to advance

Returns

The advanced iterator.

4.17.2.18 void sl_list_prepend (sl_list *list,* void * *data*)

Inserts an element at the beginning of a list.

Parameters

list	A pointer to the list.
data	A pointer to the data to add. The memory pointed to by this parameter must be dynamically allocated, as an attempt will be made to `free()` it when deleting the list.

4.17.2.19 sl_list_node sl_list_remove_at (sl_list *list,* const size_t *index*)

Removes, but does not delete, an element at an index.

Parameters

list	A pointer to the list.
index	The index of the element to be removed.

Returns

A pointer to the removed node. This should be `free()`d by calling sl_list_free_node().

4.17.2.20 void sl_list_unlock (sl_list *list*)

Unlocks a list's mutex.

Parameters

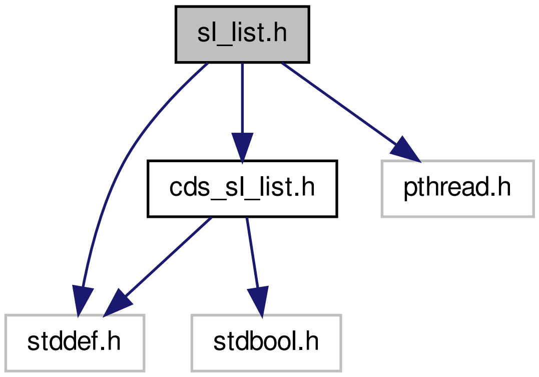
list	A pointer to the list.

4.18 sl_list.h File Reference

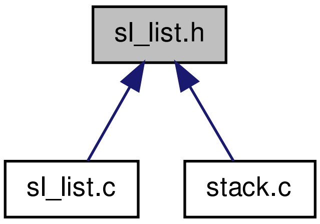
Developer interface to singly linked list data structure.

```
#include <stddef.h>
#include "cds_sl_list.h"
#include <pthread.h>
```

Include dependency graph for sl_list.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct sl_list_t

  Struct to contain a list.

Macros

- #define _POSIX_C_SOURCE 200809L

  Enables POSIX library.

Typedefs

- typedef struct sl_list_t sl_list_t

    Struct to contain a list.
- typedef struct sl_list_node_t ∗ sl_list_node

    Typedef for list node.

Functions

- sl_list_node sl_list_new_node (void ∗data)

    Creates a new list node.
- void sl_list_free_node (sl_list list, sl_list_node node)

    Frees resources for a node and any data.
- sl_list_node sl_list_remove_at (sl_list list, const size_t index)

    Removes, but does not delete, an element at an index.
- void sl_list_find (const sl_list list, const void ∗data, sl_list_itr ∗p_itr, int ∗p_index)

    Gets an index and iterator to a specified piece of data.

4.18.1 Detailed Description

Developer interface to singly linked list data structure.

Author

Paul Griffiths

Copyright

4.18.2 Function Documentation

4.18.2.1 void sl_list_find (const **sl_list** *list,* const void ∗ *data,* **sl_list_itr** ∗ *p_itr,* int ∗ *p_index*)

Gets an index and iterator to a specified piece of data.

Parameters

list	A pointer to the list.
data	A pointer to the data to find.
p_itr	A pointer to an iterator to populate with the result. This parameter is ignored if set to NULL.
p_index	A pointer to an integer index to populate with the result. This parameter is ignored if set to NULL.

4.18.2.2 void sl_list_free_node (**sl_list** *list,* **sl_list_node** *node*)

Frees resources for a node and any data.

Parameters

list	A pointer to the list.
node	A pointer to the node to free.

4.18.2.3 sl_list_node sl_list_new_node (void ∗ *data*)

Creates a new list node.

Parameters

data	The data for the new node.

Returns

A pointer to the newly created node.

4.18.2.4 sl_list_node sl_list_remove_at (sl_list *list,* const size_t *index*)

Removes, but does not delete, an element at an index.

Parameters

list	A pointer to the list.
index	The index of the element to be removed.

Returns

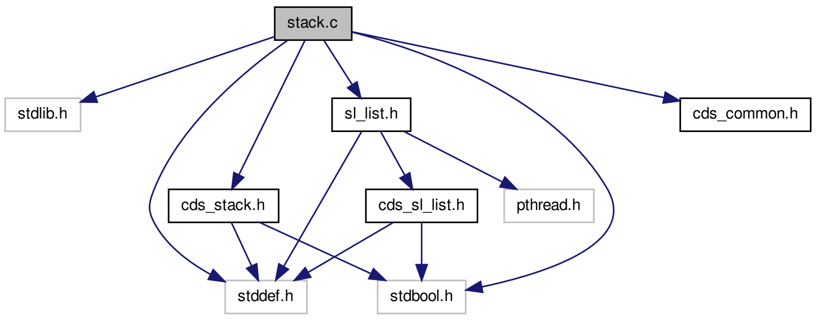
A pointer to the removed node. This should be `free()`d by calling sl_list_free_node().

4.19 stack.c File Reference

Implementation of stack data structure.

```
#include <stdlib.h>
#include <stddef.h>
#include <stdbool.h>
#include "cds_stack.h"
#include "sl_list.h"
#include "cds_common.h"
```

Include dependency graph for stack.c:



Functions

- stack stack_init (void(∗free_func)(void ∗))

Initializes a new stack.
- void stack_free (stack stk)

    Frees memory and releases resources used by a stack.
- size_t stack_length (const stack stk)

    Gets the number of items in a stack.
- bool stack_isempty (const stack stk)

    Checks if a stack is empty.
- void ∗ stack_pop (stack stk)

    Pops a data item from the stack.
- void stack_push (stack stk, void ∗data)

    Pushes a data item onto the stack.
- void stack_lock (stack stk)

    Locks a stack's mutex.
- void stack_unlock (stack stk)

    Unlocks a stack's mutex.

4.19.1 Detailed Description

Implementation of stack data structure. Implemented in terms of a singly linked, singled-ended list data structure.

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4.19.2 Function Documentation

4.19.2.1 void stack_free (stack *stk*)

Frees memory and releases resources used by a stack.

Parameters

stk	A pointer to the stack.

4.19.2.2 stack stack_init (void(∗)(void ∗) *free_func*)

Initializes a new stack.

Parameters

free_func	A pointer to a function a free a stack node. The function should return no value, and accept a `void` pointer to a node. If `NULL` is specified, the standard `free()` function is used.

Returns

A pointer to the new stack.

4.19.2.3 bool stack_isempty (const **stack** *stk*)

Checks if a stack is empty.

Parameters

stk	A pointer to the stack.

Returns

`true` is the stack is empty, `false` if not.

4.19.2.4 size_t stack_length (const **stack** *stk*)

Gets the number of items in a stack.

Parameters

stk	A pointer to the stack.

Returns

The number of items in the stack.

4.19.2.5 void stack_lock (**stack** *stk*)

Locks a stack's mutex.

Parameters

stk	A pointer to the stack.

4.19.2.6 void* stack_pop (**stack** *stk*)

Pops a data item from the stack.

The item returned was previously allocated using `malloc()`, so the user must `free()` the returned pointer when done.

Parameters

stk	A pointer to the stack.

Returns

A `void` pointer to the popped data item.

4.19.2.7 void stack_push (**stack** *stk*, void * *data*)

Pushes a data item onto the stack.

The provided pointer should point to dynamically allocated memory.

Parameters

stk	A pointer to the stack.
data	A pointer to the data item to be pushed.

4.19.2.8 void stack_unlock (stack *stk*)

Unlocks a stack's mutex.

Parameters

stk	A pointer to the stack.

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